DIGEST OF INDUSTRIAL AND TECHNICAL DEVELOPMENTS

Fuel Efficiency makes for Clean Air

SEVERAL good slogans for the industrial fuel efficiency campaign were provided by the Parliamentary Secretary to the Ministry of Fuel and Power, Mr. David Renton, when he opened the refresher course for works and plant engineers at Oxford. He stressed one lesson of the Suez crisis—that the power politics of others makes it essential for British industry to have a policy for fuel and power. He made a special appeal to firms which tend to drift, being well-satisfied with technical methods that have been considered adequate in the past, when judged solely by the immediate and narrow criteria of the business concerned. "I invite you to take a wider view of the matter, bearing in mind that you will find the national interest is identical with the firm's interest."

Referring to the fact that the Clean Air Act comes into operation and makes it a criminal offence to create dark smoke, he commented. "It is legitimate to point out to industrial firms that there is not much point in spending the money which they will, in any event, have to spend to keep within the Act, if at the same time they neglect the fuel savings which can be made. *Clean air and fuel efficiency are as inseparable as Siamese twins.*"

Petrochemicals to Produce Styrene

AT a cost of £1,750,000, a new plant for the production of styrene monomer is to be built by Petrochemicals Ltd., the subsidiary of Royal Dutch/Shell, at Partington. The plant is expected to come into operation during 1958. A considerable part of the styrene monomer output will go to Styrene Products Ltd., a Petrochemicals associate, for the manufacture of polystyrene moulding powders. It is from this plant also that the International Synthetic Rubber Consortium will draw substantial quantities of styrene for the manufacture of synthetic rubber at Fawley.

A few days after Shell announced this project, Forth Chemicals Ltd. (formed by British Hydrocarbon Chemicals Ltd. and Monsanto Chemicals Ltd.) came out with the statement that the major expansion of their styrene monomer plant at Grangemouth in Scotland had been completed and would start production in October of this year. It was in March 1954 that the plan to double the capacity of the Grangemouth plant was announced, and in a progress report issued a year later still further expansion was announced, to come into operation in 1956.

Chemical Engineering at C.R.L.

THE embryo chemical engineering department of the Chemical Research Laboratory, Teddington, was one of the most important developments to be seen at the Laboratory's annual "open days" recently held. But, so far as size and facilities are concerned, it was also one of the most disappointing sections, and it may be significant that the department—described in a recent laboratory publication as "the basis of a chemical engineering group"— was not officially on exhibition. The chemical industry, however, has special reason to be grateful to the small nucleus of chemical engineers, led by Dr. P. H. Calderbank, who are facing the difficulties brought about by material and staff shortages to pioneer this nationally important venture. In view of the representations that have been made for establishing a station of chemical engineering the point which to us would seem to call for urgent consideration is: "For how long can the country afford to have only so small a chemical engineering department within the framework of the D.S.I.R.?"

The main study being undertaken in the laboratory at present is of the dispersion of gases in liquids, with emphasis on fermentation. The problems are being looked at from a fundamental point of view, and an immediate task is to devise a way of using light-scattering methods to measure the interfacial area between a gas and a liquid in contact in an agitator vessel.

Sulphur by Fermentation

A SAMPLE of the first sulphur to be produced by a pilot plant at Beckton Sewage Works, London, using microbial action in sewage, was on exhibition in the laboratories of the Microbiological Group of C.R.L. The process was elaborated on small scale by the Group, and is based on the fact that when sulphate (e.g. gypsum) is added to a sewage sludge that is undergoing normal anaerobic digestion, methane production is inhibited by the hydrogen sulphide formed by sulphate-reducing bacteria. In the C.R.L. process the hydrogen sulphide is swept out of the sulphate-containing digester by the methane and carbon dioxide mixture produced from a normal digestion. The final mixture of hydrogen sulphide, methane and carbon dioxide should contain at least 5% hydrogen sulphide for economical recovery of sulphur. Yields of hydrogen sulphide equal to 1.0-1.5% of the sludge used have been obtained in the laboratory. The pilot plant at present under trial at the Northern Outfall Sewage Works, Beckton, in collaboration with the London County Council authorities has a 50-gallon tank and, with it, results equal to those in laboratory experiments have already been obtained. Trials on a much larger scale (200,000 gallons) are contemplated. In the radiochemistry building exhibits included an apparatus in which a method of using an ion-exchange membrane in conjuction with a counter-current system is being tried for concentrating laked uranium pulp. The successful operation of such a method would avoid difficult and expensive filtering processes.

Magnetic Refrigeration

THE magnetic refrigerator, which is a novel device for maintaining isothermally a reservoir and/or experimental apparatus at temperatures below 1°K, was the subject of the Duddell Lecture delivered to the Physical Society by Prof. J. G. Daunt of Ohio State University, U.S.A. Starting from temperatures maintained by a liquid helium

bath, this device produces cold by the magnetic cooling method, the cooling being performed in a cyclic manner. By cyclic operation temperatures below 1°K, as low as approximately 0.2°K, can be maintained continuously. In the lecture Prof. Daunt described the design and constructional problems involved and drew a comparison between the theoretically computed performance and the experimental observations of the first few magnetic refrigerators so far constructed.

The "engine" of the magnetic refrigerator basically requires, besides a paramagnetic working substance for the magnetic cooling process, thermal valves which may allow or block the flow of heat between the working substance, the helium bath and the low temperature reservoir. In the work detailed, the material for the working substance has been ferric alum and the thermal valves have been constructed from superconducting lead wires. Prof. Daunt discussed the requirements for an ideal working substance and reported experimental results on many unusual paramagnetic materials which have been investigated for use both as working substances and for reservoir materials. Amongst these ferric acetylacetonate and synthetic ruby have been found to show useful properties. Finally Prof. Daunt considered some of the possible uses of the magnetic refrigerator, for example in calorimetry below 1°K, for the establishment of an isothermal reservoir for the initiation of single stage magnetic cooling, for the production of liquid helium baths below 1°K and for the possible subsequent extension of the magnetic refrigerator to a two-stage device for the production of isothermal temperatures well below 1°K. Prof. Daunt used to work in Oxford's Clarendon Laboratory before he went across to the United States, and his current researches have special interest for the Clarendon men, such as Dr. Mendelssohn and Dr. Kurti, who are investigating the same phenomena.

British Oxygen's Research and Development

BRITISH Oxygen has formed a new private company, known as British Oxygen Research and Development Ltd. This move reflects the fact that the board of the parent company regards research and development as a separate activity equal in status and importance to the operating companies in the Group. It takes over British Oxygen's Research and Development Centre at Morden, Surrey, which has been in operation for over ten years. In addition to its programme of work for British Oxygen, the organisation is being increasingly called on to undertake work for outside bodies, including Government Departments. The board of the new company comprises the following:— Dr. P. H. Sykes (chairman), Dr. N. Booth (managing director) and Dr. L. C. Bannister. The secretary is Mr. J. W. Coates.

Evils of Industrial Life

THE important place that industrial medical officers hold in industry is not always fully recognised by the chemical engineering fraternity, who may not be fully cognisant of the health hazards of the many products handled in chemical plants. Therefore the "profound" change that has taken place in industrial medicine during the twenty-one years of the existence of the Association of Industrial Medical Officers, referred to by Dr. R. S. F. Schilling, of London University, in his presidential address to a conference held in London last month to celebrate the Association's coming-of-age, will be of wide interest. Whereas, before the war, there were about 250 industrial medical officers in Great Britain, now he said there were at least 1500, and some 400 of them wholetime. Nevertheless there was great scope for expansion as only about half of the 5000 or so factories with more than 250 workers had medical supervision, and many large commercial organisations had no medical officer or nurse. In the early nineteenth century, Dr. Schilling declared, British factory inspectors led the world in the struggle against the evils of the new industrial life. Today, as well as enforcing the law, the inspectors were using their unique prestige to persuade occupiers of factories to have their own medical services. Dr. Schilling said that it was an inspiration to him personally to meet in the London School of Hygiene and Tropical Medicine, for it was there that he had been charged with the task of building a new Occupational Health Unit; assisted by a grant from the Rockefeller Foundation, it could become a lively and busy centre of research and teaching.

The German Chemical Industry

THE spectacular recovery of the German economy since the currency reforms is an accepted fact, but the reality of it startles the visitor nonetheless. Is it possible that hard work alone, in the most unfavourable circumstances, can achieve so much in so short a time? How was the capital found without any apparent sacrifice in consumer luxuries and without a taxation burden heavier than our own? These questions which are uppermost in a visitor's mind are never answered because the Germans accept the results of their efforts as natural laws. We have similarly grown to accept our own "natural laws" and are surprised to find that they are not universal. An official visit by a foreigner to an industrial concern places on the host the responsibility of impressing and entertaining the guest without revealing any useful information concerning his process of manufacture. This generally means visits to the sales and packaging departments, and the boiler house, followed by entertainment on a grand scale. It is worth making the above fact clear so that organisations who sponsor visits of this kind shall know what they will not get for their money. The real results are the more intangible ones of learning other attitudes of mind and methods of work.

The visiting chemical engineer will have in mind the fact that chemical engineering is not accepted as a profession in Germany and will look for shortcomings as a result. After the war, people engaged in B.I.O.S. activities found such shortcomings in plenty, but in the nature of things many wartime plants were designed on the basis of expediency without emphasis on economy. Even today, it seems too early to decide the effect of this disregard of a specifically chemical engineering attitude of mind. This is because a large effort in Germany has gone into re-establishing closed-down and damaged plants. Also in the design of new units co-operation between German and international companies has sometimes masked the degree of German participation. It is abundantly clear that the pioneer German work in high-pressure techniques is paying big dividends. Steam raising plants operating at 400 atmospheres are commonplace while high pressure polythene units are being sold to the U.S.A. and elsewhere. Chemical plant fabrication techniques are very advanced using both metals and plastics. It is also apparent that a large number of plants are obsolete and have only been recommissioned by improvisation and the use of materials readily to hand. For the above reasons, the German chemical industry exhibits contrasts which make generalisations impossible. The tempo of reconstruction is, however, in line with that found in all phases of German recovery and the present seller's market, if it is maintained, will undoubtedly provide the substance for the re-growth of the industry to and possibly beyond its former stature.

Magnesium and the Earth Satellites

RECENTLY released information that the main casting of the British high-altitude rocket and the shell of the American earth-satellite to be launched during 1957 are being made of standard magnesium alloys has focussed attention on the rapidly growing number of applications for magnesium in engineering construction. Indeed, the British extractors, Magnesium Elektron Ltd., estimate that sales of the metal for the current year are 40% greater than for last year. Measures that they are taking to provide for the increasing demand include the elaboration for British conditions of a modification of the Pidgeon thermal extraction process.

A modified process on a pilot scale is already in operation at MEL's Manchester factory and the company have high hopes of being able to apply it industrially soon. The chief modification is the substitution of oil for electrical heating, the essential reaction—reduction at high temperature and under vacuum of calcined dolomite and ferrosilicon, with distillation of the magnesium—proceeding conventionally. At present the whole of the magnesium produced at the factory continues to come from the electrolytic process, a method described as "uneconomic" because of the price of electricity in Britain. The original process (of which MEL bought the sole British rights in 1936) has been improved, however, by the elimination of the need for peat in the forming of the oxychloride pellets used in the chlorination stage. In addition, a Quantometer costing £18,000 was recently installed for the rapid spectrographic analysis of metal samples while the melt is held in the foundry pot. The machine enables an accurate analytical report of impurities and the alloying metals to be sent to the foundry within about five minutes of the sample being received by the laboratory. In general, however, simple robustness continues to be the key-word for the plant design, for that quality has been found to ensure, despite the intractability of the materials handled, that the process operates without interruptions and at a low cost of plant maintenance. Currently some solid magnesium chloride (a by-product of the Canadian and Norwegian titanium industries) and magnesium in ingots is being bought by MEL to augment their home-produced supplies.

The Most Suitable Metal

THE American earth satellite is essentially an airtight hollow sphere 20-in. in diameter, made of a thin skin of highly polished alloy, and containing telemetering instruments. It is to be propelled by a series of three rockets to a height of about 300 miles and will be given a final speed of about 18,000 miles an hour to maintain it on a course nearly parallel with the earth's surface. During its flight, therefore, it will have to withstand considerable acceleration forces and, in addition, it will probably experience temperatures up to 200°C. From among a number of metals, including aluminium, titanium, beryllium and stainless steel, which were considered for its construction, magnesium was selected by the designers, the American Office of Naval Research, as having the most suitable combination of strength, lightness, heat resistance and workability. The chosen alloy (A.Z.31) contains 3% aluminium and 1% zinc. Such spheres, of skin thickness 0.032 in., are being made by first press-forming into hemispheres sheets of the alloy of 0.125 in. thickness. The hemispheres are then turned to an accuracy of about ± 0.005 in., and polished. The surface, which will be almost equivalent to that of an optical mirror, is to be protected with a covering of silicon monoxide. The interior of each sphere will contain reinforcing elements, instrument supports, etc. The two halves of each sphere will be joined either by welding or by mechanical methods.

The British high-altitude rocket will incorporate a cylindrical instrument container of about the same capacity as the American satellite. This will be propelled by a single-stage rocket motor to a height of about 100 miles, and will be subjected to similar stresses and temperatures as those experienced by the satellite. The cylinder is a casting, and for this purpose a standard magnesium alloy ZRE1, containing 2.2% zinc, 0.6% zirconium and 2.7% rare earth metals (mischmetal), has been chosen. The castings are being made by Magnesium Elektron Ltd.

Corrosion Prevention in Heaters

DESIGNERS and users of oil-fired heat transfer equipment are often faced with the dilemma that high thermal efficiency may only be obtained at the expense of the life of the heat transfer surfaces. If, however, the surfaces are to be preserved, then thermal efficiency has to be sacrificed. The reason is the presence of sulphur in the fuel oil, which when burnt gives small quantities of sulphur trioxide. If the flue or furnace gases are cooled to below the dewpoint small quantities of sulphuric acid are deposited upon the cool surfaces of the heater or furnace, which are thereby corroded. Economisers and air heaters, since they have the coolest surfaces, are the components most affected. In order to prevent such corrosion the products of combustion must leave the heater at a temperature higher than the dewpoint; thus the thermal efficiency suffers.

It was therefore interesting to hear of some promising work undertaken by L. K. Rendle and R. D. Wilsdon (reported in the *Journal of the Institute of Fuel*, September, 1956). These workers investigated the effect of introducing various materials such as magnesia, zinc dust and ammonia, into the combustion zone. Of the treatments tested, that using ammonia was found to be the most effective. The results obtained with the ammonia injection technique are striking. For example, at 93°C (46°C below the sulphuric acid dewpoint of the flue gases) the observed rate of corrosion of the steel heat transfer surfaces was 0.284 in/yr. An injection of ammonia of less than 0.1% of the fuel oil burnt was sufficient to reduce the rate of corrosion to less than 0.009 in/yr.

Although other materials for injection were successful, on a cost basis they are nowhere near so attractive as treatment with ammonia which costs less than 1.5s. per ton of fuel oil burnt. In the opinion of the authors of the paper, there are no great difficulties in applying this technique to combustion installations employing solid fuels.

Gas-lubricated Bearings

MECHANICAL Engineering Research is playing a vital and interesting part in overcoming some of the difficult pumping and gas handling problems of the chemical and nuclear energy industries. Among the applications for work pumps nowadays is the pumping of molten metals, which are used as coolants in nuclear reactors. In such applications the molten coolant becomes radioactive. The problems arising here are that normal organic lubricants will deteriorate in the nuclear radiation field; the molten coolant must be preserved from contamination by air; and, because of the strong radiation fields, the motor windings themselves must be shielded from radiation. The authors of a forthcoming paper to the Institute of Mechanical Engineers, G. W. K. Ford, D. M. Harris and D. Pantall, describe a molten bismuth pump for operating at 400°C in which the lubrication problem was solved by substituting an inert gas for the usual kind of liquid lubri-

cant. The inert gas does not affect the molten metal and is itself unaffected by radiation.

In the past, gas-lubricated bearings have been of the pressure-fed type but in this instance the bearings are self-acting and do not rely on an outside source of inert gas being fed to them. The paper gives design information for this type of bearing and discusses the results of extended tests for determining their reliability and durability. A further practical example in the field of nuclear reactor cooling is a carbon dioxide circulator. This machine, closely resembling a centrifugal pump, has a speed range of from 2000—12,000 rpm and again self-acting gas-lubricated bearings have been successfully employed. The inert gases used in both instances were either helium or argon. Silence in operation, toleration of extreme pressures and temperatures, low heat losses, and ease of cooling in the case of high speed machines are other advantages claimed for this type of bearing.

Fielden Electronics

IT is just ten years since Fielden Electronics Ltd. was formed. This company has made amazing progress in that period, transforming itself from a small concern, manufacturing one single electronic instrument for the textile industry, to the still rapidly expanding international organisation that it is today. The company now produces instruments to cover the fields of level, temperature, pressure, moisture and micro-measurement as well as textile and laboratory equipment. The chemical industry buys many Fielden instruments. The annual turnover of this company is now around £1 million.

The governing director is John E. Fielden, who founded the company in October 1946. During the war he was a naval lecturer in radar at Manchester College of Technology. After his return to the family textile business, he came to the conclusion that the textile industry did not offer enough scope for his keen interest in electronics and so he launched a company which could embark upon the production of electronic industrial instruments. Initially he and his handful of assistants made two instruments with textile applications on the top floor of a building at Holt Town, Ardwick. In those days he looked after design and development himself, but later he acquired the services of A. Worland, who is now on the board of Fielden Research Ltd. of Bangor. Production increased steadily, until in 1950 the company moved into extensive premises in Wythenshawe. This factory has twice been expanded, and the works staff has increased until today the company has about 300 people on its pay-roll.

In 1948, Mr. Fielden formed a company in the U.S.A. to sell instruments imported from England, but later manufacturing their own. This American company is no longer controlled by him, but their products are marketed under the name of Fielden Instruments, and Mr. Fielden is retained as technical adviser. An associate company has also been formed in Australia, namely, Fielden Electronics (Aust) Pty. Ltd.

Metal Fatigue—More Study Required

A SPIRITED plea for the devotion of more attention in engineering studies to metal fatigue, particularly in welds, was made by Dr. R. Weck, senior lecturer, Department of Engineering, Cambridge, in a paper to an international conference on metal fatigue held in London last month. The special fatigue problems in welded construction, he said, had been "almost completely" ignored in engineering teaching. Until this situation was remedied and designers and engineers learnt and applied what was already known, fatigue failures in service would continue to occur —possibly, he added, because of the growing use of welding on an ever-increasing scale. Nevertheless, much more information was required on the fatigue strength of welded joints in high-tensile steels and in aluminium and magnesium alloys. An important practical problem was the correlation between the quality of welds as revealed by radiographic and other non-destructive methods of inspection, and their fatigue strengths. Until sufficient data were available to present a clear distinction between relatively harmless and dangerous defects, faults revealed in such inspections would remain a subject of controversy between fabricators and inspection authorities.

Mr. P. H. R. Lane, of the British Welding Research Association, Abington Hall, Cambridge, described fatigue tests carried out on smooth seamless pipe-bends to provide a datum level with which future tests on built-up bends might be compared. For 6-in., schedule 40, mild-steel pipe bends subjected to pulsating internal pressure, he reported that the fatigue limit was equivalent to a maximum pressure of 2250 lb/sq. in., which would generate a hoop stress of 14.7 tons/sq. in. Under alternating inplace bending without internal pressure the fatigue limit was equivalent to a moment of ± 29 ton-in., which would produce a maximum hoop stress of ± 9.8 tons/sq. in.

The conference was sponsored by the Institution of Mechanical Engineers in co-operation with the American Society of Mechanical Engineers, and was attended by over 600 delegates from about 20 countries, including Japan and Russia. Later, the papers will be read to the corresponding American society, and will be published.

ICI's Plastics Technical Service

THIS year about 325,000 tons of plastics will be produced in Great Britain. This production figure is comparable with that for a number of "natural" raw materials, indeed more plastics raw material is being made annually than, for example, aluminium. As best advantage may be taken of this abundant man-made material only if it is handled with specialist knowledge during its formation into useful articles, the plastics division of I.C.I. have built, in the past two-and-a-half years, a block of laboratories at Welwyn Garden City, Herts, to help in providing a comprehensive technical service for users of plastics at home and abroad. In addition, work on the development of new plastics will be conducted in the block, which is claimed to be probably the best equipped of its kind in the world. Built in simple contemporary style and costing about £500,000 the laboratories were opened formally on September 28. They possess, in addition to conventional chemical and physical laboratories, a number of fabrication laboratories and departments for the study of compounding, extruding, moulding, colours, and lighting in relation to plastics. Work being investigated at present includes the testing of paints, of which a range is soon to be made available, containing Butakon, a copolymer of butadiene and methyl methacrylate.

Harwell's "Swimming Pool"

"LIDO", the latest research reactor at Harwell, started operating during the night of September 20/21. Intended primarily for shielding studies, one of its major tasks is to assist in the development of a submarine propulsion unit. It is a "swimming pool" type reactor and its enriched-uranium plate-type fuel elements are suspended in a large concrete tank of purified water. The reactor core is about the size of a tea chest. Shielding experiments are made by moving the core of the reactor close to aluminium windows which are set into the walls of the tank.

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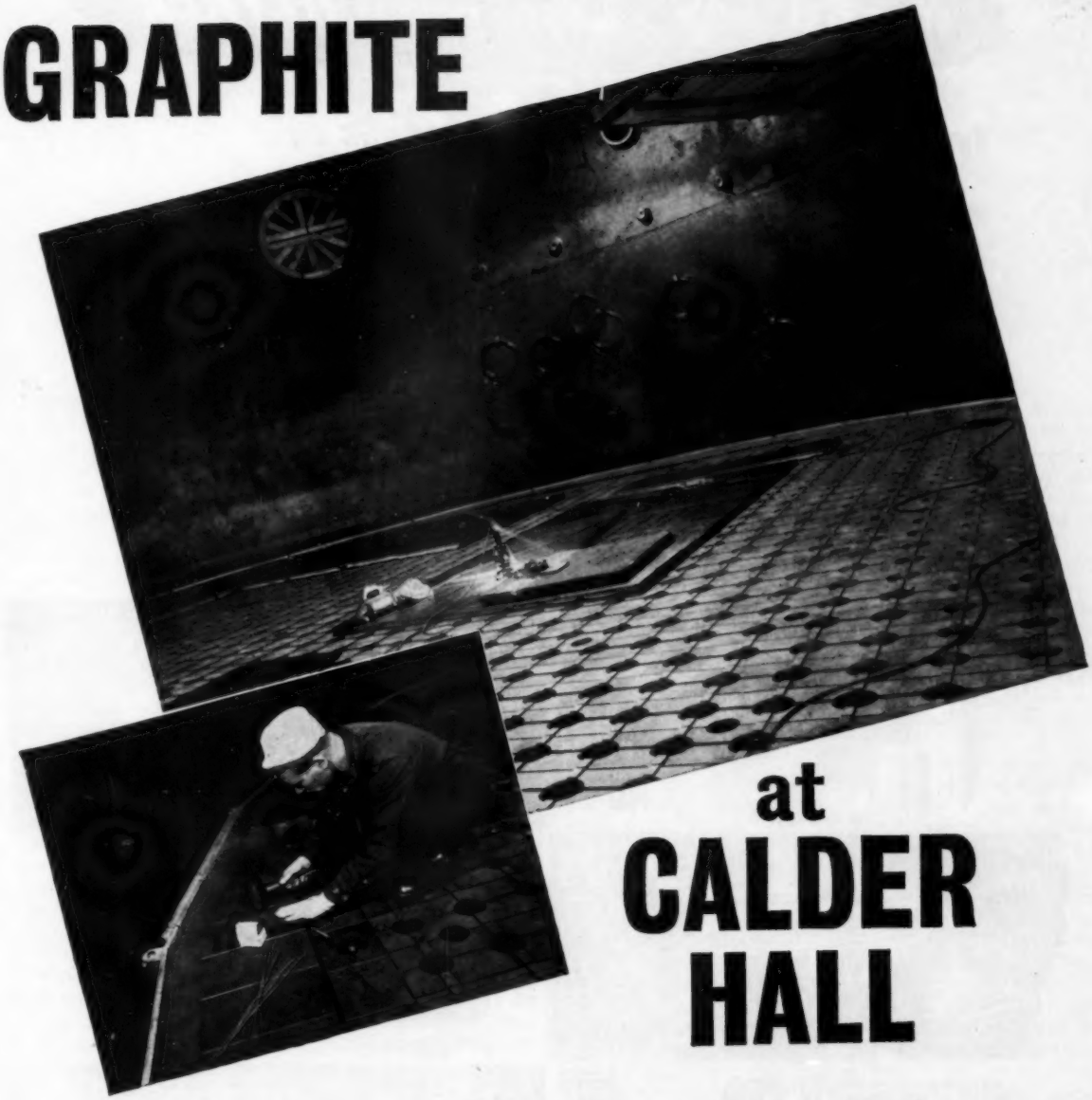

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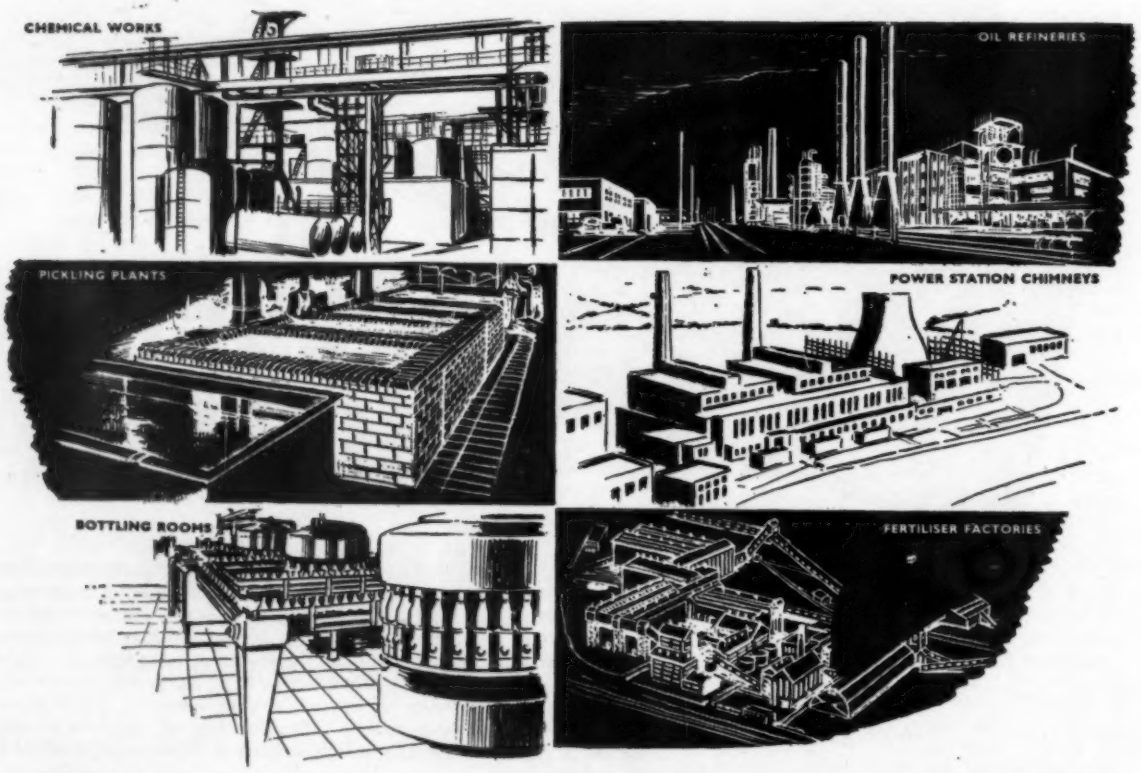

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BRITISH CHEMICAL ENGINEERING
A HEYWOOD TECHNICAL PUBLICATION

The Atomic Age

NOW that atomic power is actually flowing into the Grid from Calder Hall, it is possible to say with accuracy that the Atomic Age has started in Britain. With the commissioning of Calder Hall "A", the limelight swings on to the engineers who designed it, superintended its construction and brought it on stream. Up till now it has been the atomic scientists who have received nearly all the bouquets. Now it is up to Britain to honour the engineers who made Calder Hall possible.

In view of our acute shortage of technologists, it has been a truly tremendous achievement to create an industrial-scale atomic power station ahead of every other country. It has to be recognised, however, that the materialisation of Calder Hall has been the result of a "crash programme". The engineers have worked flat out on extremely tight schedules: schedules, moreover, which some foreign experts thought were far too tight. They have not spared themselves to get the job done on time. What they have achieved shows that Sir Christopher Hinton's deputy in the A.E.A. Industrial Group, Mr. W. L. Owen, had the measure of his men when he remarked: "If you get the right sort of chaps and form the right sort of team, they will be quite hurt if you are not pushing them hard. The happiest times have always been those when there was far too much to do." Calder Hall is indeed a monument to the policy of "so much to do: so little time to do it in".

Properly, this power station has to be regarded as a great pioneer experiment; it is essentially a beginning, not an end in itself. After a long period in which all the top men in the A.E.A. Industrial Group have been hard-driven, the time has arrived for them to take a breather. As one A.E.A. expert has put it: "We are trying to compress the time-scale in which everything is done. If you consider that in something like ten years we have moved from the point where we had nothing at all to one where we are introducing plans to spend £300 million, you can see we are moving somewhat. I think, sometimes, that we should stop and think whether we are backing the right horse or not . . . we may be rushing too quickly, on the grounds that we are largely ignorant of what is round the corner. And by taking the easiest and more obvious path, we may be sidetracking ourselves from the main stream on which it will develop in ten years time."

There is almost no limit to the variety of power reactor designs that can be visualised. The A.E.A. has to decide which are the best "new" horses to back in this field during the next ten or twenty years. It must allow its experts sufficient time to take stock and time to think. Nuclear reactors, as Sir Christopher Hinton has said, can be reasonably considered within the context of an ascending scale of specific heat-rating of their fuel elements. At the bottom is the graphite-moderated, gas-cooled reactor exemplified by the PIPPA reactors of Calder Hall. Essentially, a reactor of this type is a heavy land-based reactor, using low specific heat-ratings. It has the economic advantage that it does not need to make use of expensive and exotic materials of construction. At the other end of the reactor scale lies the fast fission reactor, which is much more highly rated but which involves the use of expensive and rare materials of construction; high ratings are necessary in order to make it economical, because the fissionable material which it uses as a fuel is extremely expensive. Sir Christopher has aptly likened the first type of reactor to the slow-speed reciprocating engine, and on this analogy the fast fission reactor would correspond to the gas turbine. What is certain is that the Calder Hall type of reactor is capable of considerable development.

At the beginning of last month the Central Electricity Authority received tenders for the Bradwell and Berkeley atomic power stations from the four industrial nuclear engineering groups — A.E.I.-John Thompson Nuclear Energy Company, the Nuclear Power Plant Company, the English Electric-Babcock & Wilcox-Taylor Woodrow Group and the G.E.C.-Simon Carves-Motherwell Bridge & Engineering Company-John Mowlem & Company Group. The four industrial groups started, of course, with the same basic data. The designs they submitted, however, showed significant differences in such matters as the size of projected nuclear reactor "furnaces", and the design of fuel elements and pressure vessels. (The cost estimates, it is to be noted, also differed considerably, a sign that no "price ring" is operating in this field.)

Now that the industrial engineers are bringing their talents to bear on the problems of nuclear engineering and now that normal commercial competition is coming into play, we may confidently expect substantial improvement of the Calder Hall—the "Model T" as it is so often jokingly called—type of reactor for power stations of 250-300 megawatt capacity. Smaller generating units (of around 15 megawatts) are also being considered very seriously by our industrial design engineers. Such units are already considered to be an excellent "export" proposition. The development of smaller nuclear power units will almost probably lead to the use of nuclear energy in the process industries as a source of heat and steam. While British industry gets busy exploiting the results of the Calder Hall experiment, the Atomic Energy Authority will be moving on and probing into new fields such as "breeding" with new installations such as the fast reactor at Dounreay. The future promises to be as profitable from the industrial point of view as it will be exciting technologically.

The Economics of the Continuous Centrifuge Process v Batch Operation

by ALAN J. HAYTER, B.Sc., Ph.D., A.M.I.Chem.E.

This model was constructed to indicate an ideal layout for a vegetable-oil-refining plant incorporating the new-type centrifuge (Sharples 26 series).

WHEN the industrial history of the twentieth century comes to be written, it will certainly show that one of the outstanding reasons for the rapid growth of a vigorous and efficient chemical and process industry could be directly attributed to the part played by the chemical engineer. An appreciation of the advantages which the rational approach of the chemical engineer could bring to process problems was slow to be realised. It is the nature of the chemical engineer to be inquisitive, and his function to investigate completely all aspects of established chemical processes with a view to increasing their efficiency. Not even the classic and traditional processes, which in some cases have been worked for more than one hundred years, can be considered as sacrosanct. These processes, in particular, demand an unprejudiced reappraisal of the basic physico-chemical operations involved, and their translation in terms of modern chemical plant practice.

Of outstanding interest has been the emergence of the continuous process as the alternative to batch processing methods. The present trend is towards the continuous process, with its many economies, unless overriding factors exist which favour the retention of batch processing.

The problems encountered in the early days of continuous operation have been largely overcome by the evolution of new techniques, and this progress has been due in no small measure to the impetus given to the work by the petroleum industry. However, a survey of existing continuous processes reveals the interesting fact that single-phase reaction systems predominate, and that multi-phase reaction systems still tend to be handled by batch methods. It is not difficult to see why this should be so. Multi-phase systems usually demand a number of liquid-liquid or liquid-solid separation stages and the separation has, in the past, been carried out by batch methods. It is an interesting commentary on the development of the chemical engineer that there has been a tendency to devote attention to the more esoteric aspects of the science and

neglect the simple operations which form such a large and important part of the average chemical process. Thus it is that there has never been any shortage of research work in distillation, heat transfer, etc., but fundamental work on such operations as mixing and separation has been neglected.

The reason for this is easily understood. In the case of separation we have at our disposal the natural phenomenon of gravity, which is readily usable and at first sight appears to cost nothing. Just how fallacious this belief is will be shown later. Gravity separation usually demands the use of batch or semi-batch operation. How, then, can continuity be developed in a process which includes the requirement of phase separation? The answer lies in the development of the continuous centrifuge, and it is fortunate that this challenge has been appreciated and met by a few specialist companies, who have concerned themselves with the design and process application of continuous centrifuges.

A comprehensive survey of various centrifuge types has been published already in *British Chemical Engineering*, June, 1956, pp. 68-73 and July, 1956, pp. 148-51. The purpose of the present article is to consider the continuous centrifuge as an aid to the development of continuous chemical processes. As an illustration, specific reference will be made to the great changes and developments which have taken place in two old-established industries: the edible oil industry and the soap industry.

The Edible Oil Industry

For many centuries oil-bearing plants have been cultivated for their yield of oil for human consumption. As the global standard of living rises, there is an increasing demand for high-quality cooking oil, salad oil, shortening, margarine, etc. The quality of oil demanded by the market has risen with its consumption and the present requirement is for a bland neutral oil having a minimum colour value and good keeping qualities. Crude vegetable oils normally comprise triglycerides of long-chain fatty acids together with free fatty acids, mucilaginous and phosphatidic compounds, colour bodies, water and solid organic matter. Before the oil can be compounded and processed into an acceptable product, a refining operation is necessary to eliminate acids, gums, water and solids and to reduce colour to an acceptable limit.

The classic batch-refining method used by the industry consisted of adding caustic soda to the crude oil in heated and agitated kettles. The exact mechanism of the refining reaction is complex, but may be simplified as follows. The gums in their anhydrous form are oil-soluble, but when they are hydrated they are thrown from solution. In this refining method the water associated with the caustic soda hydrates and precipitates the gums and at the same time the free fatty acids are saponified, giving an insoluble soap phase. The caustic soda is usually added in considerable excess, and the unreacted reagent is available for a colour reduction. After the saponification reaction, the oil must remain in the kettle for a sufficient time to allow the gravity separation of the soap phase to take place. Water is then usually sprayed on to the oil to wash out soap traces, and the wash water settled off. This may be repeated a number of times, after which the oil is vacuum-dried to eliminate moisture.

This, then, is the traditional "art" of refining as practised over many generations. In an uncompetitive market the operation had the merit of extreme simplicity, but modern conditions have necessitated a new approach in order to develop a refining technique capable of reducing the extremely high losses of saleable oil which are an inherent

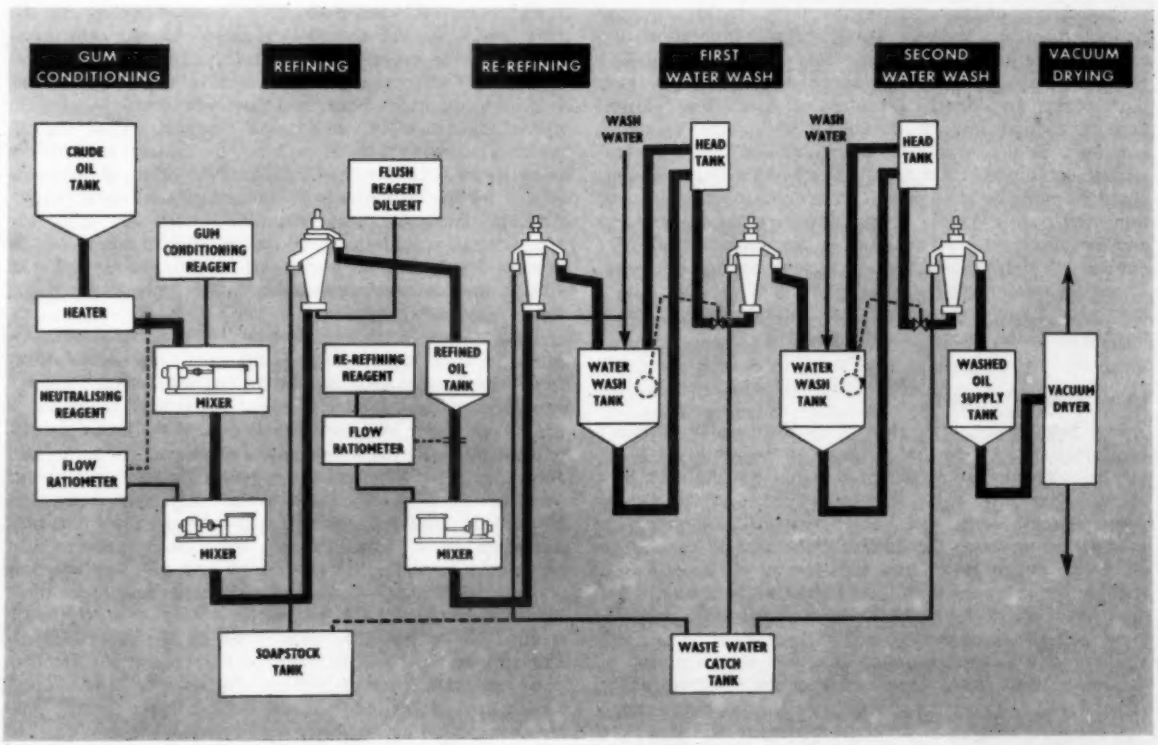


Fig. 1. The "Low Loss" vegetable-oil-refining process.

feature of the batch method. It is no exaggeration to say that refining losses are the key to the economics of the industry, and in order to survive the modern refiner has to modify his established procedures and reduce his oil losses.

The first essential step towards an increased refinery yield was a detailed consideration of how oil losses occur. The refining operation itself is designed to remove undesirable constituents of the crude oil, and therefore a certain loss is inevitable and an indication of satisfactory refining. Laboratory tests have been established for assessing this loss, which is called the Wesson Loss and which is a summation of all materials other than the neutral in the crude oil. Therefore, if the refining loss on a crude oil is equal to the Wesson Loss, the refining operation is giving the maximum yield consistent with high quality. In practice, the actual refining loss in the kettle is considerably greater than the Wesson Loss, and it is a reduction in this avoidable loss which is the problem.

Oil losses take place at a number of stages in the refining process. When the hydrated gums are precipitated they dissolve neutral oil, and this oil becomes a loss to the process. The reaction rate of free fatty acid neutralisation is instantaneous compared with that of hydrolysis of neutral oil. Consequently, little neutral oil is degraded, provided no excess of caustic soda is used above that required for acid neutralisation. Unfortunately, in order to achieve satisfactory refining in the kettle, it is necessary to use a considerable excess of caustic soda. Both the excess caustic soda and the neutral oil come into intimate contact because of their mutual solubility in the soap phase. Under these conditions hydrolysis and saponification of the neutral oil takes places and considerable quantities of high-value oil leave the process as low-value soapstock. Yet another major loss occurs when the soap is gravity settled from the oil. This gravity-settled soap entrains a high percentage of neutral oil, which is also lost to the process.

Close study of these losses reveals that a high proportion of them are a direct result of batch operation. For example, the loss by saponification of neutral oil is a result of the high excess of caustic and the long contact time, which are inherent features of batch kettle operation. The high loss of entrained oil in the soapstock is caused by the poor separation obtained under gravity-settling conditions. All this indicates that great savings could be made by changing to a continuous refining operation, and over the past twenty years continuous research and development has resulted in the introduction of a number of highly successful continuous refining processes. The most recent and the most efficient of these processes, the "Low Loss" Process, will be considered here, and a flowsheet of the process is given in Fig. 1.

Low Loss Process

The first stage of the Low Loss Process comprises a conditioning treatment for the gums in the crude oil. When the oil contains mucilaginous material which is of little or no commercial value it becomes expedient to remove gums with the soapstock. The gum-conditioning treatment is aimed at reducing the quality of neutral oil carried out of the system in association with the gums. It consists of treating the crude oil with a polybasic aliphatic acid which has the effect of changing the surface conditions of the gums and releasing neutral oil.

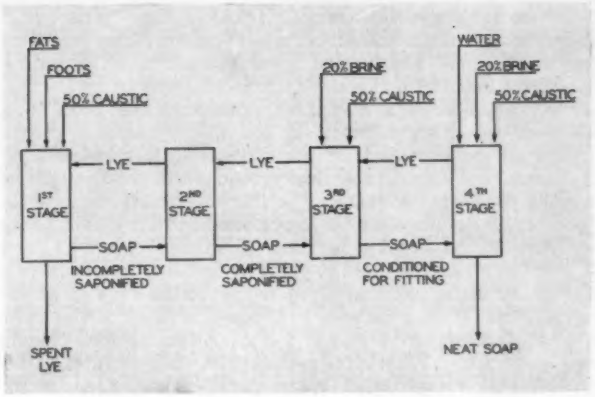
There is no separation step involved at this stage and the conditioned gums pass forward to the first neutralising stage. The oil is now treated with the stoichiometric quantity of caustic soda required to neutralise the free fatty acids. The use of a theoretical treat means that there is no excess of caustic soda available for undesired neutral oil saponification. The soap and oil phases are separated in a continuous centrifuge under conditions of high gravity. This not only gives a clean break of phases, but also releases entrained oil from the soapstock, thereby increasing the oil yield. The refined oil now passes forward into a re-refining stage where a considerable excess of caustic soda is employed. However, oil losses in this stage are maintained at a very low level; as, although there is an excess of caustic, there is virtually no soap phase present to serve as a surface catalyst for the hydrolysis of neutral oil. This refining stage reduces the colour and eliminates the final traces of fatty acid. The oil then passes into two water-wash stages which remove soap traces and again the phases are continuously separated in a centrifuge. The washed oil passes into a continuous vacuum dryer and is discharged as a high-quality, dry refined oil.

The success of this process has been due to the co-ordinated engineering of all the equipment. Short contact time between oil and saponifying agent is necessary in order to minimise losses. This has necessitated the design of a special high-efficiency, low-capacity mixer which provides sufficient contact surface without forming unbreakable emulsions. In addition, since the quantity of caustic soda added is critical, accurate yet robust proportioning devices have been introduced which are capable of holding the caustic addition as a fixed percentage of the crude oil flow under conditions of continuous operation.

The heart of the process, however, is the continuous centrifuge, and very careful attention has been given to the selection of the correct machine for this application. In making the selection it is necessary to bear in mind the precise function the machine is to fulfill. It is well known that the structure of soapstock formed on refining is sponge-like. By making simple analogy to a sponge, it is readily seen that the greater the squeezing force applied the greater the amount of liquid expressed from the sponge. The length of time that the sponge is squeezed has little effect on the amount of liquid expressed. Soapstock, essentially, behaves in the same manner, and the length of time the soapstock remains in the centrifugal field has little effect on the quantity of entrained neutral oil, while the centrifugal force applied to the soapstock is all-important. The problem here is essentially a three-phase separation. Apart from the separation of the oil and soap phases, there is also the possibility of the presence of solid matter which must be removed from the oil for further processing. The choice of centrifuge, therefore, is predicated on a machine which will efficiently separate two liquid phases and retain a solid phase, can be readily dismantled to remove the solid phase, and will subject the separated soap phase to the highest centrifugal force.

Two types of centrifuge could be considered for this purpose. They are the large-diameter, medium-speed, disc-type centrifuge, or the small-diameter, high-speed, tubular bowl centrifuge. The disc-type centrifuge generates a centrifugal force of between 6000 and 8000 times gravity, whereas the tubular bowl centrifuge develops centrifugal forces up to 16,000 times gravity. Moreover, the tubular bowl machine has the advantage that it can readily be cleaned in a few minutes, while the disc machine requires extensive time and labour for cleaning. Practical experience, both in the laboratory and in the plant, has shown that the high centrifugal force of the tubular bowl machine results in the soapstock having a much lower neutral oil content than that given by the disc machine. For this reason, the majority of the continuous refining processes have standardised on the tubular bowl Super-Centrifuge, and of the total installations at the present time the overwhelming majority are fitted with this type of machine.

To summarise, therefore, the Low Loss Process gives



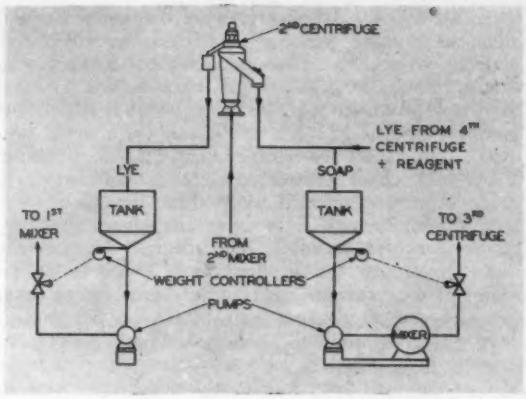


Fig. 2 (left). A diagrammatic representation of the flow through the Continuous Centrifugal Soap Process.
Fig. 3. Shows the equipment incorporated in a typical single stage of the process.

the following positive advantages over the kettle refining method.

Low Losses. The losses of neutral oil are much lower than those obtained with the conventional batch-refining system, and show a saving in loss of neutral oil from between 25 to 40%.

High Quality. In addition to producing more oil, the continuous process gives an oil of very high quality as regards colour, moisture, free fatty acid and soap content.

Ground Space. The total amount of material being processed at any one time is a fraction of that in the kettle system. This means that the ground space requirement for the continuous plant is considerably lower than that required for an equivalent-capacity kettle unit.

Flexibility of Operation. In kettle operation it is difficult to isolate the various stages of refining. The continuous Low Loss Process is subdivided into six stages, and each stage can be selected to give the correct operation best suited to the particular oil under treatment.

Labour. The total labour requirement for the continuous process is, of course, much lower than that of a kettle refinery. In addition, unlike the kettle process, which depends upon highly skilled operators with many years of refining experience, the continuous process may be operated by semi-skilled operators, since the process variables are controlled by the proportioning equipment. Continuous refining processes are in operation in nearly every country of the world and, in particular, they, are finding increasing favour in primary production areas such as Africa and the Middle East. Here the standard of process labour is low; but, nevertheless, consistently high results are obtained from the continuous equipment. There is virtually no size limitation and plants are in operation having capacities varing from 10 to 600 tons per day.

The savings which can result from the substitution of continuous refining into an existing kettle house may be seen from the following balance sheet, which is based on actual results obtained at a plant which made this changeover.

Economic Comparison of Refining Methods for Cottonseed Oil

	Batch	*Continuous*
Free fatty acid	3.67%	
Moisture	0.46%	
Gums	1.30%	
Wesson Loss	6.33%	
Refining Loss	**10.68%**	**7.10%**

This means that, if the plant has a capacity of 30 tons of oil per day, the continuous plant would give an increased yield of 1.07 tons per day over the batch process. In assessing the value of this production to the refiner, it must be remembered that as the neutral oil yield increases, so the soapstock yield decreases. Therefore, the profit from increased refined-oil production must be balanced against the loss of soapstock. At the present time the value of refined oil is in the region of £120 per ton, and the value of cottonseed black grease is £32 per ton.

An estimate of the increase in refining profits from the Low Loss Process is given by the following simplified calculation:

$$1.07 \times £ (120 - 32)$$
$$= £94 \text{ per day}$$

In terms of annual operation, this can mean an increased recovery of oil valued at £28,000. This financial analysis does not take into account the improved quality of centrifugally refined oil, but this is a significant feature. The use of the centrifuge ensures that the oil is substantially free from soapstock and moisture and therefore has excellent keeping qualities. The rapid processing in the continuous refinery results in an oil of lower colour, which often means that the amount of earth required in the subsequent bleaching operation can be reduced. The loss of oil absorbed by the earth is thereby minimised.

No economic comparison can be complete without a consideration of all factors involved. Both the continuous and batch refining systems make similar demands on utilities and reagents. The capital cost of continuous refining equipment is certainly higher than the equivalent batch equipment. However, if consideration is given to the reduced building cost and the reduced inventory for the continuous plant, the differential becomes small. This differential in capital cost has to be balanced against the increase in profits, and usually the increased cost can be paid off in one year or less. These are the sort of economics which have caused over 200 refiners in all parts of the world to change to continuous refining.

The Soap Industry

The soap industry has an unbroken history of about 2000 years. During this period there has been a great advance in the understanding of the saponification reaction. The home-rendered tallow and wood ash, which were early raw materials, have been replaced by sodium hydroxide and a wide range of vegetable and animal oils. This wide variation in oil formulations has resulted in a greatly extended range of end-products. Nevertheless,

these advances have not been accompanied by similar advances in the equipment used. Until recently the large majority of soap was still manufactured in kettles under the supervision of highly skilled soap boilers. The quality of soap produced is entirely in the hands of these specialists, whose task it is to estimate the completeness of the chemical reactions by their highly developed senses.

The basic chemical reaction in the manufacture of soap is the saponification of fatty material by caustic soda to give sodium salts of fatty acids and glycerine. The glycerine recovered from the saponification reaction contributes greatly to the profitability of soap-making, and soap-making methods which do not allow for recovery of the glycerine from the soap mass are becoming less common. The "full-boil" soap-making process consists of reacting fatty material with caustic soda in the presence of salt, and subsequently washing out glycerine. This operation is usually carried out in four basic stages or "changes":

(1) The fat is almost completely saponified to give two phases: spent lye containing glycerine and salt, and grained soap containing unsaponified material and salt.

(2) The saponification is completed by treatment with additional lye. Once again two phases are formed: a grained soap phase, and an undepleted lye which can be used for the saponification of subsequent fat charges.

(3) The grained soap is washed one or more times to remove glycerine, and the electrolyte content of the charge is adjusted to prepare for the finishing operation.

(4) The electrolyte concentration of the mass is adjusted so that the soap, which has previously been in an open grain form, now separates with a liquid neat soap as a light phase, while the impurities and colour bodies are concentrated in a heavy "nigre" phase.

Soap boilers introduce many modifications into the number and sequence of these charges, but the various operations fall under these main categories.

The full-boil soap-making process in the kettle is a time-consuming business. In addition to the time needed to fill the pans and for the reaction to take place, additional and considerable time is required to gravity separate the phases at each stage. The total time taken varies from 5 to 10 days, and this extended holding time makes heavy demands on steam, labour and ground space.

The inefficient washing in the kettle causes large volumes of lye to be used to bring the glycerine content of the soap to the required level and recover a maximum quantity of glycerine. In practice, the spent lyes seldom contain more than 5% of glycerine and this throws an excessive load on the glycerine evaporators. Consideration of the soap-boiling process indicates that if the time taken for reaction and separation could be reduced by continuous operation, then great savings could be made in operating costs. In addition, improvements would be made in soap quality because there would be less degradation of colour, etc.

A number of high-pressure, high-temperature, continuous fat-splitting processes have been developed, in which the fat is first hydrolysed to give fatty acids and glycerine sweetwater and the fatty acids are subsequently distilled and saponified. These processes are, in general, only applicable to the large soap maker who can countenance the capital expenditure and the difficulties of operating high-pressure steam boilers.

A great need has always existed for an economical continuous soap process which follows the chemistry of

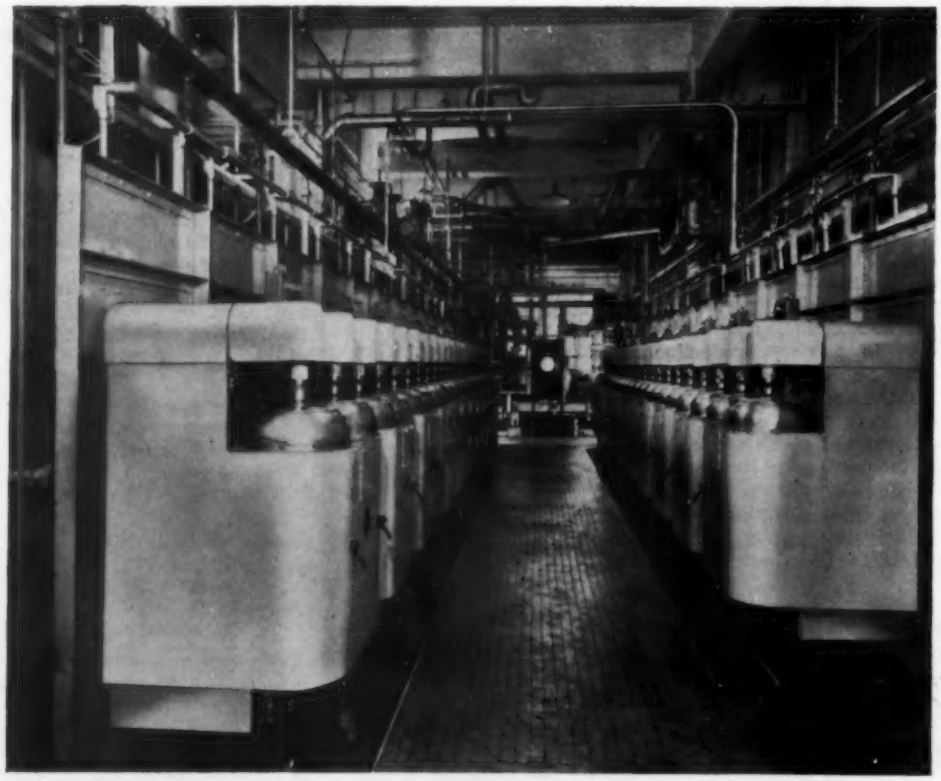


Fig. 4. This illustration was taken in a Chicago vegetable-oil-refining plant, one of the largest of its kind in the world. The centrifuges shown are the Sharples 26 series.

the traditional kettle saponification reactions, and which could be applied to the small soapery. The key to the problem is in the difficult separational steps involved, and once again the answer has been provided by the tubular bowl Super-Centrifuge, which can continuously separate soap and lye phases in a centrifugal field of 13,200 G. Over the past fifteen years the Sharples Continuous Soap Process equipped with these Super-Centrifuges has been developed and installed with outstanding success in soap factories all over the world.

A diagrammatic representation of the flow through the Continuous Process is given in Fig. 2, from which it will be seen that the conversion of the fat to neat soap takes place in four stages. The flow through these stages is truly counter-current, with soap passing forward through the plant and being conditioned and washed by lye passing in the reverse direction. The total time for processing is of the order of two hours, the maximum temperature is 220°F and the maximum pressure is 20 psig.

Fig. 3 shows the equipment incorporated in a typical single stage of the process. The soap-lye mass from the previous stage is separated by the Super-Centrifuge into its constituent phases, any dirt being retained in the machine. The separated soap is combined with the necessary reagent for the subsequent stage, passes through a flow control tank into a continuous mixer, and on to the next stage. The separated lye passes back through a flow control tank to act as reagent for preceding stage. The process is extremely simple to operate and one man per shift is the usual labour requirement. This is made possible by the automatic control of all flows. All feed streams are introduced through linked proportioning units, and the flow rates between stages are held constant by flow controllers. Temperatures in the feed heaters and in the various mixers are also automatically controlled.

Plant experience with the Continuous Process has proved its great economic advantage as compared with conventional systems. The comparison between the Continuous Process and the Kettle Process given below is based upon actual operating data. However, so diverse are kettle soap-making procedures that it will not necessarily reflect conditions obtaining at all plants. Many kettle-houses have a considerably less efficient operation than that discussed. Alternatively, modern counter-current kettle techniques would have an increased efficiency. However, the comparison does reflect the fact that the Continuous Process represents a great step forward in transforming soap making from being an art into being a science.

Economic Comparison of Soap-making Methods

Fat processed per year	4000 tons
Soap produced per year	6000 tons
Glycerol content of fat formulation ...	10%
Steam cost	£1 per ton
Power cost	1d. per kWh

Steam for Soap Boiling. The processing time from fat to neat soap in the Continuous Process is approximately two hours compared with the many days required in a kettle house. This short reaction time results in a greatly decreased steam usage for soap boiling, and for the maintenance of sensible heat levels in the kettles.

Kettle: 1.5 tons of steam required per ton of fat.
Continuous saponification 0.22 tons of steam per ton of fat.
Cost saving with continuous saponification:

$$= 4000 \times (1.5 - 0.22)$$
$$= £5120 \text{ per year}$$

Steam for Glycerine-Lye Evaporation. The use of true counter-current flow in the Continuous Process, together with the high-efficiency mixing and separating stages employed, gives a high recovery of glycerol without the use of large volumes of wash liquor.

Kettle: 1.25 tons of spent lye per ton of fat.
Continuous saponification: 0.54 tons of spent lye per ton of fat.
Glycerine evaporation: Approximately 0.8 ton of steam is required to treat 1 ton of spent lye.
Cost saving with continuous saponification:

$$= 4000 (1.25 - 0.54) \times 0.8$$
$$= £2272 \text{ per year.}$$

Glycerine Recovery

Loss of available glycerol occurs at a number of points in the soap process. In particular, these losses are caused by inefficient washing of the soap and by the lye treatment which is necessary before evaporation. In addition, there is a loss during evaporation. The Continuous Process recovers a greater percentage of available glycerine because of the highly efficient washing employed and because the volumes of lye being handled are smaller. The spent lye from the centrifuge is bright and free from suspended material, and this simplifies the lye treatment operation.

Kettle: 85% overall glycerol recovery, including loss in kettle house, lye treatment and evaporation.

Continuous saponification: 90% minimum glycerol recovery, including loss in process, lye treatment and evaporation.

Taking the price of crude glycerine (80%) as £185 per ton, the Continuous Process gives increased recovery of glycerol valued at:

$$4000 \times 0.1 \times (0.9 - 0.85) \times \frac{185}{0.8}$$
$$= £4620 \text{ per year}$$

Fat Degradation. In the kettle house, soap is held over long periods of time at high temperatures and in contact with the atmosphere. The resultant oxidation invariably leads to colour degradation. Moreover, the soap in the kettle may contain much suspended matter which must be removed in order to produce specification soap. The soap boiler therefore adjusts the electrolyte concentration at the fitting stage to produce an upper layer of high-quality neat soap and a lower layer of a low-quality "nigre" which preferentially concentrates the impurities. This "nigre" soap cannot be used for top-quality household or toilet soaps, but is often used in powder soaps and bulk laundry purchases with a subsequent loss in value.

In the Continuous Process the time factor is short and the soap flow is enclosed. Also, four stages of centrifugal treatment remove all traces of suspended impurities. This dispenses with the need for a "nigre" fit, and the final stage of the centrifugal soap process is a separation of neat soap from lye. It is not easy, in this case, to assess the financial gain from continuous operation. However, an indication of savings are given by the following calculations.

Value of fat formulation for household and and toilet soaps ... ... £85 per ton
Value of fat formulation for low-grade soaps £70 per ton

A typical percentage of fatty material removed as nigre might be 12%. It is common practice to reuse the "nigre" to commence the saponification reaction in subsequent soap boilings. If the nigre is reused four times, the discard from each boiling is effectively 3%. There is no discard from the continuous process which produces two effluent streams only, neat soap and spent lye. Therefore the saving is:

$$-4000 \times 0.03 \times (85 - 70)$$
$$= £1800 \text{ per year}$$

Material Loss in Spent Lye. The two-stage saponification

and centrifugal separation used in the continuous process ensures an extremely low concentration of fatty material and caustic soda in the spent lye.

Kettle: 0.5% caustic soda in spent lye.
Continuous saponification: 0.1% caustic soda in spent lye.

Caustic Lost to Spent Lyes:

Kettle: $4000 \times 1.25 \times 0.005 = 25$ tons
Continuous saponification: $4000 \times 0.54 \times 0.001 = 2.2$ tons

The saving from the continuous process is therefore 22.8 tons per year of caustic soda, valued at £600. The additional fat recovered from the continuous process has been found to have a value of approximately £1000.

Electricity. The kettle house uses electricity only for transfer pumps, whereas the Continuous Process makes demands on electric power for centrifuge and mixer drives, etc.

Kettle: 5 units per ton of fat processed.
Continuous: 70 units per ton of fat processed.
Extra cost of continuous process = $4000 \times (70 - 5) \times 1$d. = £1083 per year

A summation of these items indicates that the use of the Continuous Centrifugal Soap Process in place of the old kettle method gives a saving of £14,330 per year. This comparison does not tell the whole story, since there are many advantages of the Continuous Process to which financial weight has not been given. The neat soap produced is lighter in colour and brighter than that produced in the kettle from similar stocks. The raw material inventory is, of course, very greatly reduced. The space requirement is low: a plant producing 1 ton of soap per hour can be accommodated in a two-storey building measuring 25 x 35 x 33 ft.

In this article the far-reaching changes brought about by the centrifuge in the soap and edible oil industries have been considered. Other similar processes have been developed, now replacing batch equipment in other industries and are being used, for example, for grease recovery, tar dehydration, soapstock acidulation, and for low-temperature fat-rendering. Another development nearing perfection is a continuous process for the recovery of tall oil from soap skimmings from the sulphate pulp process in the paper industry.

Henry Gethin Davey, O.B.E., works general manager responsible for Calder Hall, Windscale Works and Annan. He will be 48 next month.

Davey of Calder Hall

OCTOBER 17, when the Queen pressed the switch to connect Calder Hall with the Grid, was a proud day for many people. For Risley men like Sir Christopher Hinton, W. L. Owen, B. L. Goodlet and R. V. Moore, and for K. L. Stretch, the works manager of Calder Hall. And, in particular, for H. G. Davey. As works general manager of the north-western region of the Atomic Energy Authority, Davey is responsible for Calder Hall and the similar unit which is under construction on Annan airfield, as well as for the Windscale plutonium factory. (The linkage of these three units is a logical administrative arrangement, for the plutonium produced in the power reactors will be extracted at Windscale.)

Nowadays Davey is almost the best-known name in atomic energy apart from the five "atomic knights", and one or two scientific types, such as Dr. Dunworth of Harwell. Yet Fleet Street remained totally unaware of his existence until 1952!

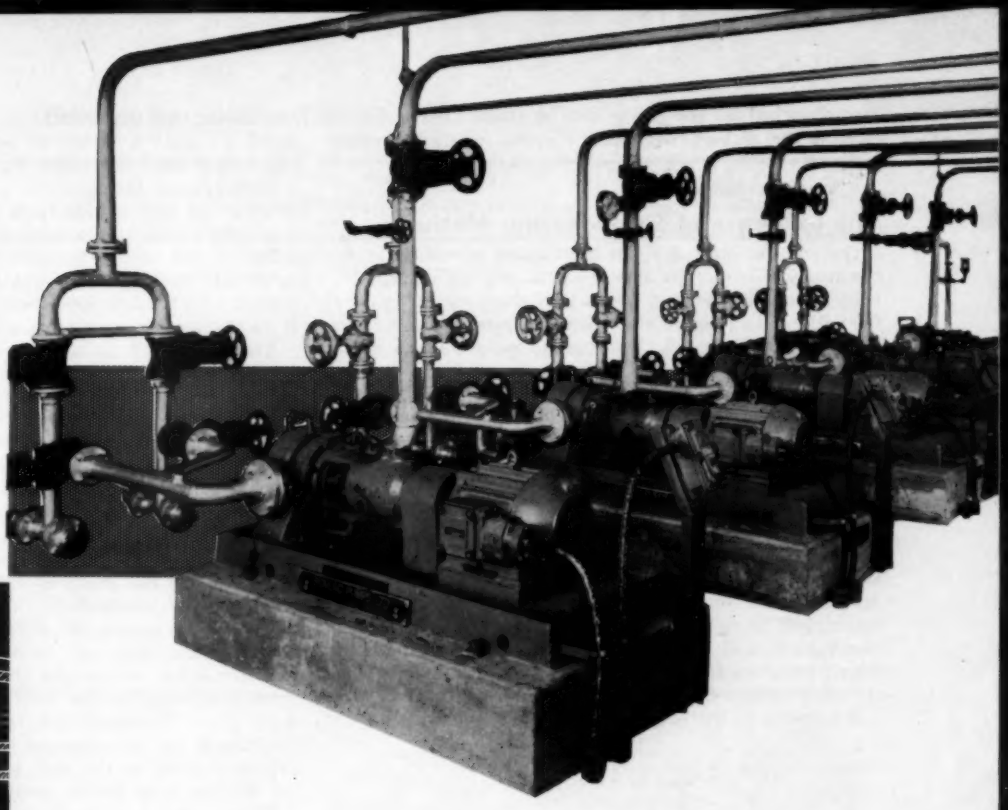
The day may eventually arrive when "nuclear engineering" acquires the character of a separate technology, but at the present time it is essentially an amalgam of the established branches of engineering, an amalgam that has a big content of chemical engineering in it. Couple the versatility of the good chemical engineer with a real talent for administration, and one has the ideal man to manage the important group of atomic enterprises in Cumberland. Before the war Davey had been a lecturer in chemical engineering at the Glamorgan College of Technology, Treforest. The war took him, in turn, to the Royal Ordnance factories at Pembrey and Drigg. Eventually, he became deputy superintendent of three R.O.F.s—Drigg, Sellafield and Bootle.

In 1947 Sellafield was chosen for conversion into a plutonium-producing unit, and Hinton picked Davey as the works manager of this factory (which was given the name of the Windscale Works). The Windscale piles started up in July, 1950, and the first irradiated fuel elements were taken out of the reactors in December, 1951. In a matter of weeks these had "cooled" sufficiently for Davey to proceed and give the order for the separation plant to be brought on stream, which produced the explosive for Monte Bello and subsequent tests. In the 1952 Birthday Honours List Davey's work at Windscale was recognised by the award of an O.B.E.

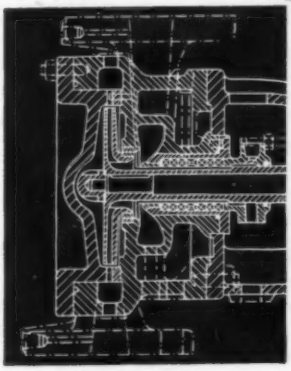
Davey has proved himself much more than just a good technologist. He has an inspired vision of the relationship between atomic energy developments and the general prosperity of West Cumberland. He has, for instance, most progressive ideas about the way local talent should be brought into the atomic energy projects located in this region. He regards it as wasteful to employ on unskilled work a man who is capable of filling a technical post. His attitude is epitomised in the advice he gives to local schoolboys with a definite bent towards science or engineering who inquire about career prospects at Windscale. Wherever the boy is bright enough, Davey advises him to obtain his degree and then to come back and take up a technical post in an A.E.A. establishment. On behalf of the A.E.A. he has done great missionary work, and has devoted much time to explaining the importance of the atomic factories to rotary clubs, chambers of commerce and the like. The rank and file at Windscale have a high opinion of their W.G.M., who does everything to ensure that the working conditions in his plants are as good as possible.

Davey's work is his life, and it leaves him with little spare time to relax and to indulge in his hobbies—gardening and music. The first of these two interests accounts for the fact that the grounds of Calder Hall are already floristically more attractive than those of Harwell.

WILLIAM E. DICK.



A group of single-stage diffuser-type centrifugal pumps at an oil refinery. Details of construction and design of this type of pump are shown in the inset.



Selection of Pumps for the Chemical and Process Industries — Part 2

by
J. O. S. MACDONALD
B.Sc., A.R.I.C., A.M.I.Chem.E.

Centrifugal-pump Characteristics and Automatic Flow-control Systems

Frequently the flow produced by a centrifugal pump is controlled by throttling the discharge by means of a motor valve used in conjunction with a flow controller. Two difficulties can arise with such systems that have a bearing on pump selection and the design of its environment.

First, assuming the pump to have the normal head-capacity curve, where the maximum head is developed at zero capacity the conditions at the pump suction must provide sufficient NPSH for the pump to be able to give the maximum rate of flow from the installation (Fig. 13). For example, in a given case the control valve is to be three-quarters open when the maximum flow rate is established. This rate will correspond to a certain NPSH required by the pump, and unless this value, or more, is provided by the plant then the required maximum flow will not be attained. The control valve will attempt to rectify matters by opening still further, but owing to the NPSH deficiency its action will be in vain. Therefore, in flow-control systems incorporating centrifugal pumps, the correct NPSH conditions must be created or pumps with suitable suction characteristics selected. This point is also worthy of attention where constant flow is obtained by means of a piston type of pump.

With centrifugal pumps the second difficulty that can arise concerns pumps with the kind of head-discharge characteristic wherein the maximum head is not developed at zero but at some real value of the capacity (Fig. 14). A controller operating in the section of the head-capacity curve up to this point would require to close the control valve to increase the rate of flow, whereas in the stable part of the curve it would have to open to increase the flow, which is an impossible task with the usual range of instruments. Pumps with this type of characteristic should not, therefore, be used in systems employing automatic control of flow by throttling of the pump discharge.

The Significance of NPSH

The preceding discussion may be summarised as follows:

(1) NPSH affects the selection of pump type inasmuch as the centrifugal operates better than the other types available under conditions which provide only a small margin of system NPSH over pump-required NPSH.

(2) Once the type of pump has been decided, attention must be given to NPSH, both in relation to the pump specification and to the location of the pump.

(3) Where the choice falls upon a centrifugal, the pipework scheme must provide an NPSH margin of 3 ft over that required by the pump at the design throughput. The pump should be chosen so that it will operate at somewhere near its maximum efficiency. Unnecessary development of heat in a pump through operation at low efficiencies tends to reduce the developed suction lift, since

heat absorbed by the pump can be transferred to liquid entering the suction connection, thereby raising its vapour pressure.

The Influence of Shaft-sealing Methods

One of the most difficult mechanical problems in the construction of pumps employing a rotating element has been the development of satisfactory shaft-sealing methods for withstanding high temperature and pressure, and corrosive and volatile fluids. Some pump-makers use a 4-ring stuffing box for discharge pressures up to 70-80 psi. The proper operation of this type of shaft sealing depends upon a small amount of leakage—to reduce the amount of heat generated and to provide lubrication. For this reason this kind of seal cannot be used with liquids whose presence outside the pump would be hazardous.

When the pump is working under vacuum the slight leakage at such a gland will not be effective because air will be sucked in, and the outward liquid leakage necessary for lubrication will be limited. To get round this difficulty, one make of pump causes the gland to be submerged in a fluid harmless to that being pumped. Mechanical seals may also be used in this arrangement, which possesses the advantage that a failure at the gland is indicated by a fall in the level of the sealing fluid.

Returning to the subject of the hazards which may be caused by the slight leakage necessary at an ordinary gland, there are a variety of courses which the pump-user can follow depending upon the severity of the hazard.

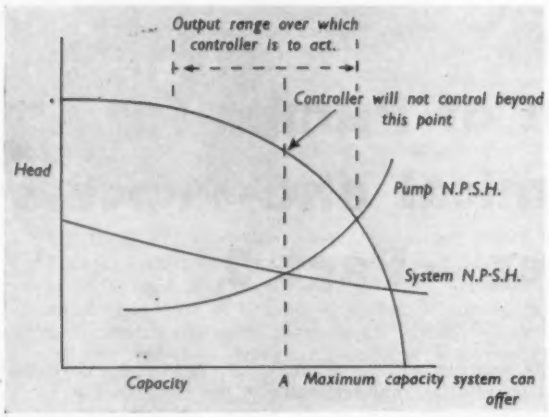


Fig. 13. Automatic control of flow in a system employing a centrifugal pump. For successful operation, NPSH of system must agree with that required by the pump.

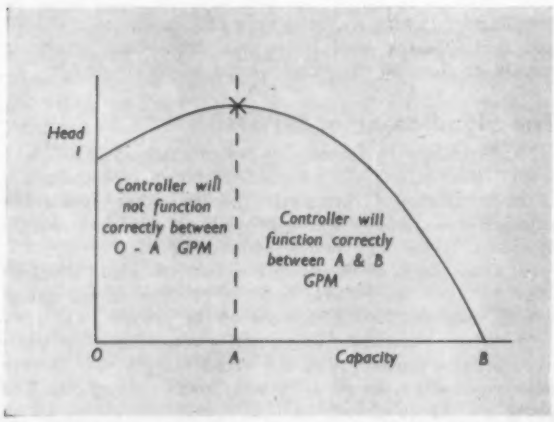


Fig. 14. Control of flow in system employing centrifugal pump. Initial portion of pump head capacity curve shows that pump is unsuitable for automatic flow-control systems.

First he may use a deeper stuffing box; for example, a six-ring box with lantern rings may be used up to 400 psi. Such boxes may have a connection to the pump suction in order to reduce the pressure against the packings. The outermost packings with this type of gland have to be provided with lubrication, because the amount of leakage is insufficient for good lubrication.

The next resort, especially where high pressures have to be met, is the mechanical seal, which has become most popular and has tended to displace the older type of gland. A strong point in its favour is that it does not require adjustment.

The principle of the mechanical seal is to replace the normal gland packing by two antifrictional mating rings, one of which rotates while the other is stationary. Actually a variety of shaft seals are available dealing with a wide range of conditions, such as pressures up to 600 psi and as low as 1 mm Hg absolute, while temperatures as high as 250°C can be tolerated.

Difficulties associated with these seals are that they require lubrication, may be damaged by fluids containing abrasive solids and require cooling. The former condition is often satisfied by the very slight leakage which usually takes place. However, this, too, may be undesirable and the leakage can be prevented in part by the addition of an ordinary gland to the shaft-seal assembly. In such cases the leakage must be run away to a container.

Where such a measure is not satisfactory, the choice lies with a glandless pump of which a variety are available. Some centrifugal pumps achieve this by mounting auxiliary blades at the back of the impeller in order to create a suction at the point where the impeller shaft passes through the pump casing.[1] This later may carry a simple, shallow stuffing box as a precautionary measure for a shut-down pump. Pumps of this type are used for low heads and for handling slurries.

Another form of glandless centrifugal pump in wide use is the vertical pattern. This type finds applications in which vacuum or high pressure are not involved, and where the leakage caused by liquid climbing up the shaft can be run back into the vessel from which the liquid is being pumped. They are often fitted directly into the vessels from which they are to discharge, or otherwise they are connected to the vessels as closely as possible. In the former case the shaft leakage is returned quite readily to the vessel; but in the latter case a separate connection from pump to vessel is necessary. Pumps having shaft lengths up to 24 ft are available.

Where the duty merits it, the diaphragm pump, by virtue of its absence of gland, may often prove a suitable choice.

Where a centrifugal type is the choice and when the duty involves fluids that are hazardous, such as radioactive media, the older type of glandless centrifugal will not suffice, particularly where the temperature and pressure are high or where the operations are under vacuum. For such conditions two useful solutions are available as shown in Figs. 15 and 16. The first shows a diagram of a "canned rotor" pump wherein the rotor of the squirrel-cage motor is fitted and sealed inside a protective can which, in turn, is mounted inside the pump. In this way the gland is dispensed with (Fig. 15).

The other interesting design (Fig. 16), which is becoming widely used, employs an enclosed pump which is coupled magnetically to a separate driving shaft. In this pump, two rings of permanent magnets, one on the driving shaft and the other on the pump shaft, with their poles facing one another are separated by a small gap. The magnets on the pump shaft are separated from those on

Table 2. Range of Available Chemical Pumps

TYPE OF PUMP	APPROXIMATE CAPACITY (GPM)	MAXIMUM HEADS DEVELOPED (ft. Water)	MATERIALS OF CONSTRUCTION	REPRESENTATIVE MANUFACTURERS
CENTRIFUGAL HORIZONTAL	10-1200	150	Regulus metal. Special alloys if required	Tangye
	10-1000	100	C.I. 18/8/1 and special Nickel alloys	LaBour
	10- 700	300	C.I. 17/10/3 stainless steel and other alloys	Hayward Tyler
	10- 700	130	18/8/3, 24/20/3 and others	Worthington-Simpson
	20-1200	150	C.I. Bronze 18/8/3 and others	Pulsometer
	5-1200	250	Bronze 18/8/3, Nickel, Hastelloys	Sigmund Pumps
	10- 600	150	C.I. Bronze, 18/8/3 Hastelloys	Appleton & Howard
	1- 800	800 (multistage)	C.I., Bronze, 18/8/3, Nickel, Plastics, Hastelloy-type alloys	Ryaland
	5- 900	120-150	C.I. 18/8/3, Hastelloy-type alloys	Girdlestone Pumps
	20- 60	30	Stainless steels	Alfa-Laval
	5- 900	120	C.I. Bronze, Nickel, 18/8/3, Hastelloy-type alloys	Drysdale
	1- 35	45	Bronze, C.I., Stainless, Electro-Tinned surfaces	Stuart Turner
	25- 500	250 or higher	C.I. Bronze, Nickel, 18/8/3, Hastelloy-type alloys	Mather & Platt
	20-3000	200	C.I.-Bronze, Ebonite lined	Rhodes, Brydon & Youatt
	5- 300	300	Bronze, 18/8/3, Hastelloys, Nickel	Howard Pneumatic Engineering Co.
	4-3000	Up to 1000 (multistage)	C.I. Bronze, 18/8/3, Hastelloys	Gwynnes Pumps
	10- 70	40	Stainless steels	Apex Construction
	30-1500	150	C.I., Bronze. Special alloys if required	Hamworthy
	15- 600	100	Stoneware	Pulsometer
	5- 500	100	Stoneware	Hathernware
	5- 500	100	Stoneware	L. A. Mitchell
	10-3500	80-100	C.I., lined natural rubber	Wilkinson Rubber Linatex
	5- 200	100	Hard rubber	Dexine Rubber & Ebonite
	2- 240	25-65	Hard rubber	Silvertown Ebonite
	20- 300	150	Keebush, P.V.C.	Kestner
	2- 30	90	P.V.C.	Horwitch Smith
	10-1000	75	Impervious Graphite	British Acheson
GLANDLESS CENTRIFUGAL	10-1000	100	C.I. 18/8/3, special Nickel alloys	LaBour
	20- 300	150	18/8 P.V.C. Keebush	Kestner
	12- 500	60	Rubber lined	Denver
	10- 200	350	Iron, C.I. Bronze, 18/8/3, Nickel Alloys	Hydraulic & Pneumatic Developments
	—	—	—	Chempump
	15- 500	75	C.I. Bronze and special materials	Lee Howl
VERTICAL CENTRIFUGAL	5- 300	300	Bronze, 18/8/3, Hastelloy alloys, Nickel	Howard Pneumatic Engineering Co.
	10-1000	150	C.I. Body, Alloy impeller, 18/8 type S.S.	LaBour
	30-2500	100	C.I., Rubber lined	International Combustion
	12- 500	60	C.I., Rubber lined	Denver Equipment
	5- 900	120	C.I. Bronze, 18/8 type S.S. Nickel	Drysdale
	4- 35	40	C.I. Bronze Other alloys if required.	Girdlestone
	20-1300	150	C.I. Bronze. Other alloys if required	Sigmund Pumps
	20-3000	200	C.I. Bronze, Ebonite	Rhodes, Brydon & Youatt
CENTRIFUGAL SELF-PRIMING	10-1000	100	C.I. 18/8/1 and special Nickel alloys	LaBour
	40- 300	150	18/8/1 P.V.C. Keebush, etc.	Kestner
	5- 50	30-40	C.I. Bronze, Nickel, 18/8/3	Drysdale
	30-2500	100	C.I., Rubber lined	International Combustion
	10- 700	300	C.I. Bronze	Worthington-Simpson
	20-1500	140	C.I. Bronze	Sigmund Pumps
	20- 220	50	C.I. Bronze	Wayne Tank & Pump Co.
	20-1200	150	C.I. Bronze. Special materials if required.	Lee Howl
	7- 450	200	C.I. Bronze. Other materials if required	Hamworthy
	20-1200	150	C.I. Bronze	Pulsometer
	2- 30	90	P.V.C.	Horwitch Smith
POSITIVE-DISPLACEMENT PUMPS (PISTON OR PLUNGER)	20-1000	300 (or more)	C.I. Bronze. Iron and special alloys such as 18/8/3	Dawson & Downie
	40- 300	150	18/8, P.V.C.	Kestner Evaporator
	3-1900	300-700	C.I., Iron, Bronze and special materials if required	Hayward Tyler
	20- 340	300	C.I. Bronze	Worthington-Simpson
	20- 400	300	C.I. Bronze	Joseph Evans
	2-1000	300	Acid-resisting Bronze, All Iron	Tangye
DIAPHRAGM	6- 10	230	Bronze, C.I., Ebonite-lined	Girdlestone Pumps
	½- 110	200	Bronze, C.I., 18/8/3 body	S. H. Johnson
	2- 75	120	Plastic sleeves, carbon, P.V.C. valves	Merrill
	6- 8	25	Aluminium or C.I. Natural and synthetic rubber linings	Wilkinson Rubber Linatex
	2- 200	25	Iron, C.I., Rubber lined	Denver
	10	30	Stoneware body	L. A. Mitchell
ROTARY (GEAR, etc.)	20- 125	230	C.I.	Wayne Tank & Pump Co.
	½- 500	700	Nitralloy steel	Hamworthy
	8- 350	200	18/8/3 and other special alloys	Howard Pneumatic
	5- 150	400	Bronze, Monel	Stothert & Pitt
	½- 450	500	C.I., Stainless steel, Monel	Albany
	3½-2000	350	C.I., Iron, 18/8/1, 18/8/3	Drum Engineering
SLIDING VANE (OR SIMILAR TYPE)	6- 80	100	C.I.	Douglas
	1- 150	200	C.I. Manganese steel	Comet Pumps
	1½- 35	50	Plastic, 18/8, Bronze bodies, rubber or plastic impeller	British Quadruplex
	13	25	Stoneware	L. A. Mitchell
	2- 5	60	Silicon iron	Kestner
	10- 250	230	C.I. Meehanite	Hamworthy Engineering
MISCELLANEOUS ROTARY	½- 280	1100	C.I., Stainless steel, etc.	Plenty & Sons
	2.7- 18	575	C.I., or Gunmetal	Pulsometer
REGENERATIVE	1- 30	300	C.I., Bronze or Monel Impeller	Worthington-Simpson

the driving shaft by means of a sealing shroud bolted to the pump casing. This type of coupling is being used with centrifugal pumps of conventional design, but there does not seem to be any reason why it should not be incorporated in a design of self-priming pump. Such a combination would be of interest to the chemical engineer.

Cost of Pumps

The selection of a pump type is frequently influenced by the cost. It is not within the scope of this article to give a detailed account of pump costs, nor how cost varies with throughput. However, the following approximate scale is given to show how cost varies among different types of pump for about the same capacity, and how different materials of construction for the same type affect cost.

Output 50 gpm, head 50 ft		
Centrifugal Pump	Cast-iron construction	1.0
	Bronze	1.2
	Cast steel	1.3
	18/8/1 stainless steel	1.9
	18/8/3 stainless steel, high nickel alloys	2.0
	Cast-iron self-priming	1.3
	Cast-iron vertical	1.2
Positive Displacement		
Reciprocating	Cast iron	2.8
Plunger	Cast iron	2.6
Diaphragm	Cast iron-rubber	1.8
Positive-displacement Rotary		
	Cast iron-cast steel	1.2
	Bronze	1.5
	18/8/1 stainless steel	1.8
Peripheral (nearest capacity)		
	Cast iron-bronze	1.3

Self-priming Pump Applications

Occasions may arise where the centrifugal type is suitable but where the nature of the installation or material handled requires a self-priming pump. It is in this field that the centrifugal meets its most serious challenge from other types, such as the rotary. In such circumstances a non-centrifugal pump or a self-priming centrifugal may prove worthy of attention.

Self-priming pumps of various kinds are used in the following situations:

(1) Continuous or intermittent flow at suction lift installations.

(2) Intermittent pumping, where generally the volume of undissolved gases exceeds 5-10%, if the choice is a centrifugal pump.

(3) Pumping away from evacuated vessels intermittently.

The circumstances which cause the design engineer to adopt suction lift conditions vary considerably. Some are listed below.

(a) The vessel whose contents are to be discharged is without a bottom discharge.

(b) The location of the liquid to be transferred may not lend itself to flooded suction conditions, for example, liquid is contained in a sump below ground level or in a tank buried underground for safety reasons (Fig. 17).

(c) The fluid to be pumped makes lubrication of the normal type of gland impossible; one solution is a glandless pump. In this case, if a centrifugal is the choice, the flooded suction installation must be avoided and the pump must operate under suction lift conditions.

(d) The nature of the fluid makes pressure at a normal packed gland undesirable. For example, if the liquid contains abrasive solid particles, pressure would force these between the packing and shaft, thereby causing rapid wear of the shaft and failure of the gland. To ensure that the gland is not under pressure, a suction lift installation is required (Fig. 18).

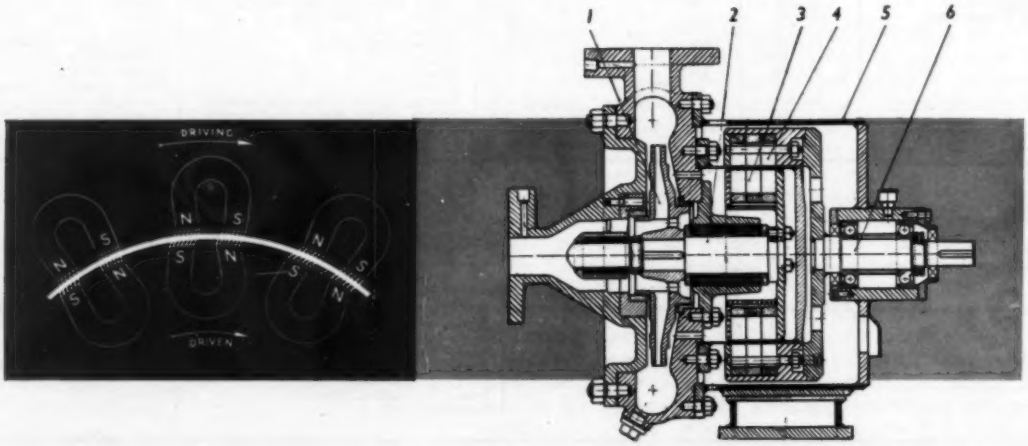


Fig. 16. Glandless centrifugal pump with pump isolated from prime mover. Drive transmitted by magnetic coupling. (Hydraulic & Pneumatic Developments.) 1. Drive shaft; 2. Impeller shaft bearing; 3. Magnet on pump; 4. Magnet on driving shaft; 5. Outer casing; 6. Driving shaft and bearing.

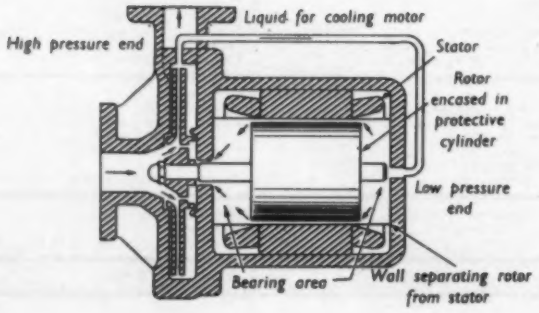


Fig. 15 (left). Glandless electro-submersible pump with motor rotor enclosed and separated from stator.

(e) At plant sites offering very little headroom, self-priming pumps sometimes give more convenient plant layout than flooded suction pumps.

(f) On completion of a pumping operation little or no fluid must be left in the pipelines; to meet this demand, the pump must be placed above the level of liquid. This might be the case if volatile or corrosive fluids, or solutions likely to leave crystalline deposits on standing, are to be handled.

It must not be concluded that the foregoing excludes other solutions to the problems listed. For example, not all vessels without a bottom run-off are discharged by a self-priming pump; compressed air, submersible pump or evacuation of the receiving vessel may each be a suitable solution, depending upon the circumstances. Similarly, the difficulty in (c) might be overcome by the use of a self-lubricating shaft seal. Furthermore, if a normal centrifugal is used, suitable priming gear may be included in the installation. However, many users prefer a self-priming pump if the fluids to be pumped have properties that make manual priming unpleasant, messy or hazardous.

Self-priming Centrifugal Pumps

Self-priming centrifugal pumps may be divided into two main groups:

(a) Pumps which self-prime by virtue of small additional vessels which allow the pump to function during the priming period as a wet vacuum pump. Some pumps falling within this rough classification employ jets which direct the fluid into the impeller eye during the priming operation.

(b) Centrifugal pumps to which are fitted separate, smaller, positive-displacement pumps capable of exhausting air from the main pump. Some of these pumps employ an impeller with positive-displacement properties mounted on the same shaft as the centrifugal impeller.

Pumps in category (a) are the most widely used in the process industries and it is interesting to observe that the jet priming pumps are the subject of considerable research, as is borne out by the recent paper of Mikhail.[11] The second group of pumps is not generally intended for chemical service; the fact that they are more complicated and not available in the wide range of materials of the first class tells against them.

Materials of Construction

Choice of materials of construction is part of the general process of pump selection. The centrifugal has an advantage over other types in that its simplicity of construction allows it to be made in a much wider range of materials than any other type. The factors influencing the selection of materials are mechanical strength, resistance to thermal shock, resistance to corrosion, the avoidance of product contamination and, finally, cost.

A pump in the more resistant of two available materials may be *more* expensive in total cost than a cheaper pump, employing less resistant materials, which has to be replaced more frequently.

Table 3 gives some of the materials used in the construction of pumps with some examples of common applications. When tests are required materials it is well to recognise that corrosion tests under static conditions can be misleading, since the effect of violent liquid movement, especially with simultaneous cavitation, can be much more destructive of material.

The following rough rules are occasionally employed in selecting materials for pumps.[12]

Acidic aqueous solutions (excluding HCl):
*p*H 0-4, use a stainless steel pump

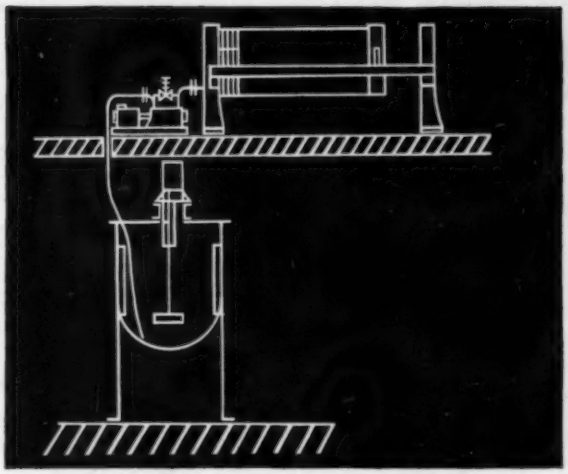


Fig. 17. Moineau-type rotary pump shown here feeding slurry to filter press from vessel below filter.

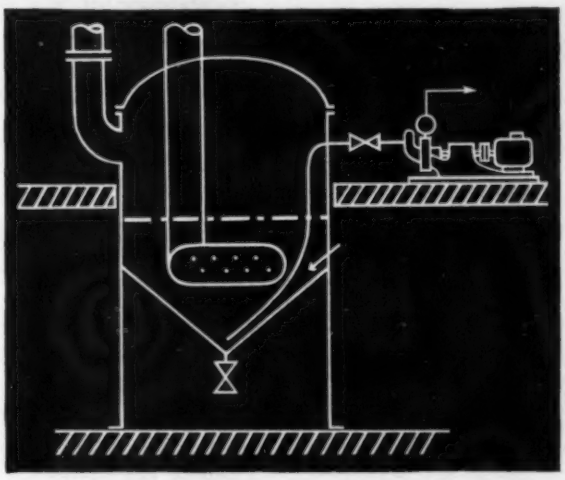


Fig. 18. Self-priming centrifugal pump used in ammonia sulphate manufacture. With this layout, abrasion of shaft and gland by crystals in the slurry is avoided.

Mildly acidic or mildly alkaline solutions:
*p*H 4-6, use a bronze or gunmetal pump
Neutral solutions and mildly alkaline:
*p*H 6-9, use a C.I. pump
For alkaline solutions:
*p*H 9 or greater, use all-iron pump

Since different parts of a pump, whatever its type, are subjected to different conditions of corrosion and mechanical stress, one often finds dissimilar materials used in a single construction. In centrifugal pumps, for example, shafts have to withstand the torque of the driver and axial-thrust of the impeller. Corrosion will be more pronounced where the fluid velocity is highest, consequently valves of reciprocating pumps and impellers and casings of rotating pumps will be more prone to corrosion than parts away from zones of high turbulence.

In selecting or buying a pump for handling aqueous solutions it is always wise to bear in mind the possibility of corrosion arising from dissimilar metals or alloys in a construction. If these have to be used, then they should either be as close together as possible in the galvanic

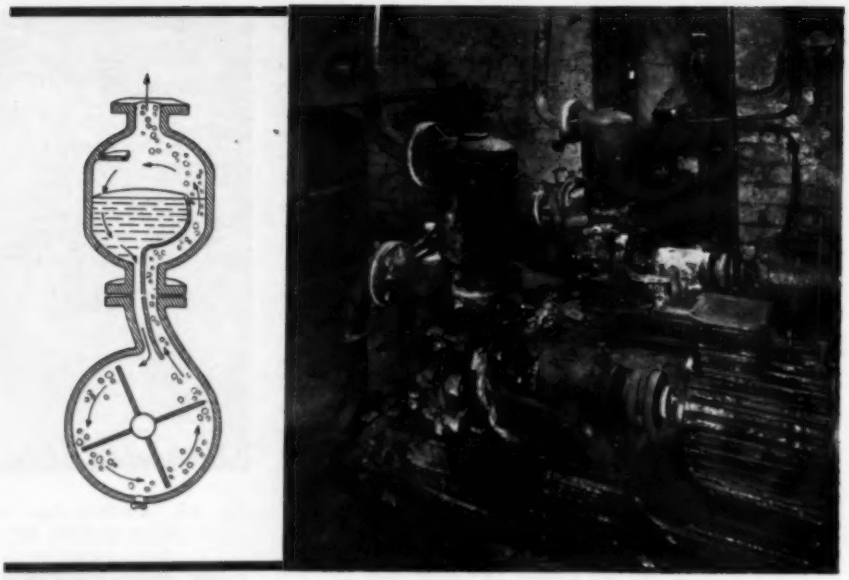


Fig. 19. Diagram (left) of self-priming centrifugal pump showing method of priming by means of a separating vessel placed at delivery. Illustration (right) shows a self-priming centrifugal pump at work on a chemical plant (British LaBour).

series or else the non-rotating parts, such as the casing, should be anodic to the impeller and of much greater area than the latter.

Galvanic Series

Corroded end (anodic)	Nickel
Magnesium	Brasses
Aluminium	Bronzes
Duralumin	Nickel-copper alloys
Zinc	Copper
Cadmium	Chromium-iron (passive)
Iron	Chromium-nickel-iron (passive)
Steel and cast iron	Silver solder
Chromium-iron (active)	Silver
Chromium-nickel-iron (active)	Gold
Soft solder	Graphite
Tin	Platinum
Lead	Protected end (cathodic)

Pump Selection and Installation Design

The following is an example of pump selection and installation design. The final details of a vacuum distillation plant are to be fixed. A pump is required to transfer the bottom product to tanks in which the product is to be stored at atmospheric pressure. The problem is outlined diagrammatically in Fig. 20, apart from selecting a pump, it is necessary to fix the position of the heat exchanger and to determine the height of the column above the pump. The latter is to be installed at ground level.

The following are the main details of the problem.

Fluid temperature at reboiler	... 120°C
Fluid vapour pressure at reboiler temperature	... 15 mm Hg
Vacuum at column base	... 15 mm Hg
Temperature of fluid leaving heat exchanger	... 30°C
Vapour pressure of fluid at 30°C	... 5mm Hg
Mean viscosity	... 3.5 centipoises
Pressure loss in suction piping	... 2 ft of fluid
„ „ in heat exchanger	... 2.5 psi
„ „ in the piping system alone	... 2.5 psi
Pressure drop across the control valve at max. flow	... 2.5 psi

Table 3. Common Materials for Pump Construction

Type of Material	Parts of Pump Constructed	Special Limitations (Mechanical and Corrosion Resistance)	Typical Fluids Handled
Aluminium	Casing, impeller	Strong alkalis, temperature	Nitric acid, sulphurous acid, fatty acids
Cast iron and cast steel	Casing, impeller, valve, plungers, shaft	Temperature	Ammonia, caustic soda solutions, glycols, alcohols, molten sulphur
High silicon cast irons	Casing, impeller	Brittleness, thermal shock	Phosphoric acid, nitric acid (less than 50%)
High nickel cast irons	Casing, impeller	Thermal shock	Brines, alkalis, alkali salts solutions, sulphryl chloride
Austenitic stainless steels	Casing, impeller, shaft		Mixed acids, fatty acids, oleum, chlosulphuric acid, nitric acid
Special Fe-Co-Ni alloys	Casing, impeller, shaft		Mixed acids, phenols
Nickel	Casing, impeller	Oxidising acids	Molten caustic soda, phosphorus oxychloride
Nickel-copper alloys	Casing, impeller	Oxidising acids	Hydrofluoric acid, dilute
Nickel molybdenium iron alloys	Casing, impeller, shaft		Hydrofluoric acid, phosphoric acid
Ni-Ci-Cu-Mo alloys	Casing, impeller		Sulphuric acid, phosphoric acid
Copper base alloys	Valves, casing, impeller, shaft	Solutions of polyvalent metals	Formic acid, aldehydes, organic chlorides, alkaline salts
Lead	Casing, impeller, valves, plungers	Temperature	Hot sulphuric acid, phosphorus oxychloride
Ceramic materials	Casing, impeller, plungers, valves	Thermal shock	Most acids, except hydrofluoric
Impervious graphite	Casing, impeller	Temperature, oxidising acids	Sulphuric, hydrochloric acids
Plastic (with and without fillers)	Casing, impeller, valves, linings, diaphragms	Temperature, oxidising acids	Hydrochloric and sulphuric acid solutions
Rubbers and synthetic elastaners	Linings, diaphragms	Temperature, oxidising acids	Hydrochloric and sulphuric acid solutions

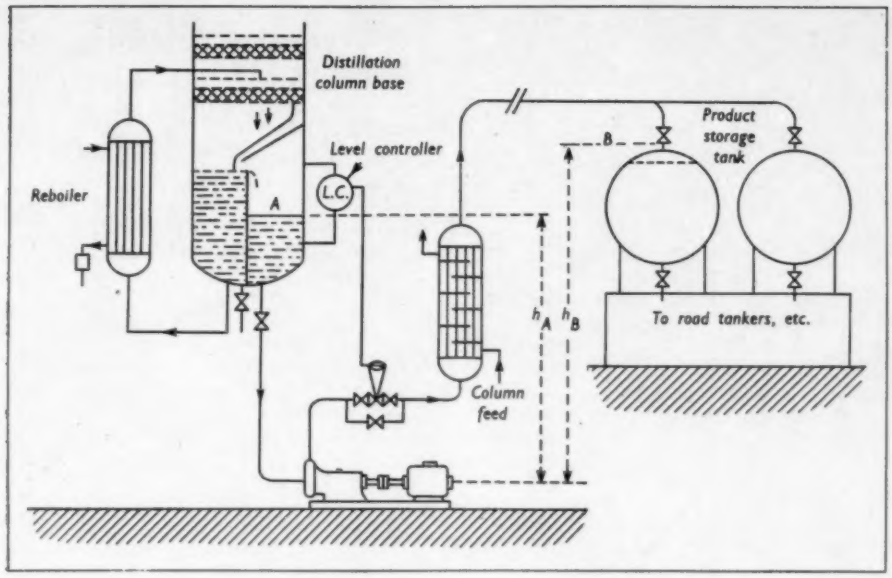


Fig. 20. Pump-selection problem. In addition to choosing a pump with suitable characteristics, the elevation of the distillation column and the position of the heat exchanger have to be fixed.

Required output ... ... 50 gpm*
Elevation of discharge point *B* above the centre line of pump ... 15 ft

In the problem as outlined it is assumed that the pipeline losses have been determined and that the control valve is so selected that it absorbs about ⅓ of the total frictional losses at the maximum through-put.

Finally, the fluid is clean and possesses lubricating properties.

Following the principle of selecting a centrifugal pump first and discarding the choice if the conditions are clearly unfavourable, we will settle on a centrifugal for the particular duty. The presence of a control valve for throttling the flow from the delivery is a factor reinforcing this selection.

Total Head on the Pump

This part of the problem is best solved by ignoring the heat transfer in the system and carrying out a mechanical energy balance at states *A* and *B*.

Thus the sum of the various kinds of mechanical energy at *A*, i.e., potential, kinetic, the energy possessed by the fluid by virtue of its pressure and volume and the energy added by the pump, are equated to the sum of the same kinds of energy at *B* plus the frictional losses in the piping system. This is expressed mathematically as follows:

$$h_a + \frac{V_a^2}{2g} + p_A v_B + W_p = h_b + \frac{V_b^2}{2g} + p_A v_B + F \quad \ldots.(9)$$

where h_a = sum of elevation of fluid at *A* and its absolute pressure in ft of fluid ($h_A + p_A$);
h_b = sum of elevation of fluid at *B* and its absolute pressure in ft of fluid ($h_B + p_B$);
V_a, V_b = velocity of fluid at point *A* and *B* respectively;
g = gravitational constant;
W_p = work done on fluid to produce flow ft lb./lb.
F = frictional losses in ft fluid; and
v_A, v_B = specific volume of fluid at positions *A* and *B* respectively, cu. ft/lb.

Thus, the work done by the pump on the fluid is given by

$$W_p = (h_b - h_a) + \frac{V_b^2 - V_a^2}{2g} + p_b v_b - p_a v_a \quad \ldots.(10)$$

and since these terms are expressed as head of fluid, W_p is equivalent to the head against which the pump must work.

In the problem the symbols have the following values:

h_A = unknown and is to be determined;
h_B = 15 ft;
V_A = negligible;
V_B = 6 ft/sec.;

$$V_A, V_B = \frac{1}{1.25 \times 62.4} = 0.0128 \text{ cu. ft/lb.};$$

$$p_A = \frac{34}{1.25} = 27.2 \text{ ft};$$

$$p_B = \frac{15}{760} \times \frac{34}{1.25} = 0.54 \text{ ft};$$

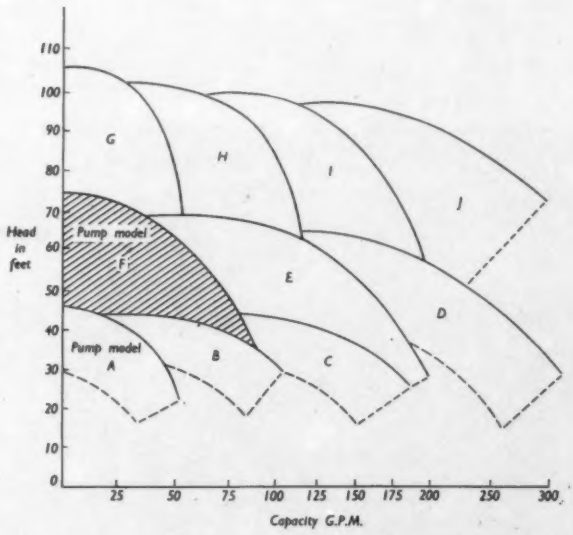


Fig. 21. Pump-selection chart. Areas denote performances of particular pumps, depending upon impeller dimensions. In the problem, Pump F was selected initially.

* *To compensate for wear in the pump it is necessary to provide a margin of about 20 gpm above the required output figure.*

$$F = \frac{7.5}{14.7} \times \frac{34}{1.25} = 14 \text{ ft of fluid.}$$

Thus, the total head against the pump is $W_p =$

$$(15 + 27.2 - 0.54 - h_A) + \frac{36}{64.4} + (0.0128 \times 26.7) + 14$$

whence $W_p = 56.6 - h_A$ . . . . (11)

At this stage a first selection can be made. From manufacturers' selection charts, such as is shown in Fig. 21, a pump with a performance similar to that required can be made, i.e., 70 gpm at a total head of about 50 ft.

Let us suppose the initial choice falls upon a pump running at 1440 rev./min. and with the following characteristics (see Fig. 23):

Output 70 gpm. Total head 45 ft. NPSH 9.5 ft water.
Output 50 gpm. Total head 65 ft. NPSH 6.5 ft water.

The height of the liquid level (h_A) at the base of the column above the pump is given by

$$W_p = 45 = 56.6 - h_A$$
$$\text{and } h_A = 11.6 \text{ ft.}$$

We have now to find whether placing the pump in this position will permit its NPSH requirement to be met.

From Equation (3) of Part I of this article (see October issue, p.304)

$$H_s = H_p - (NPSH + 3) - H_v - H_f.$$

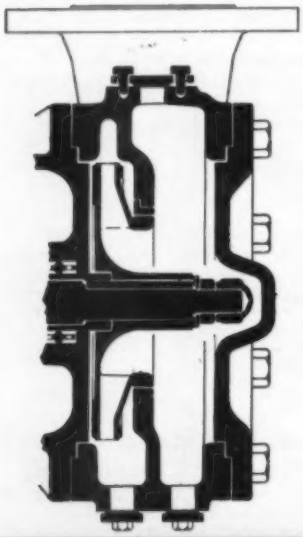


Fig. 22 (left). Pump-selection problem. Cross-section of pump suitable for vacuum service. Note the gland on the pressure side of the pump (Rhodes, Brydon and Youatt). Fig. 23 (below). Pump-selection problem. Head capacity and NPSH capacity for choice of pump (Pump F) in Fig. 21.

Where the heat exchanger is fitted on the discharge side of the pump, the symbols will have the following values:

$H_v = 0.54$ ft of fluid
$H_p = 0.54$ ft. of fluid

$$NPSH = \frac{9.5}{1.25} = 7.6 \text{ in ft fluid}$$

$H_f = 2$ ft

For this arrangement the suction lift is therefore given by

$$H_s = -(7.6 + 3 + 2) = -12.6 \text{ ft.}$$

The negative sign means that a suction head of 12.6 ft must be provided over the pump. In these circumstances the total head will be

$$W_p = 56.6 - 12.6 \text{ ft}$$
$$= 44 \text{ ft.}$$

This matches the performance of the pump sufficiently to make any further trials unnecessary.

In the case where the heat exchanger is placed in the suction line, the following values of the variables in Equation (3) apply.

$$H_v = 0.18 \text{ ft}$$
$$H_p = 0.54 \text{ ft}$$
$$H_f = 2 + 4.6 = 6.6 \text{ ft}$$
$$\text{Thus } H_s = 0.54 - 10.6 - 0.18 - 6.6$$
$$= 16.8 \text{ ft.}$$

In this case an elevation of 17 ft will be required.

The total head on the pump for these conditions will be

$$W_p = 56.6 - 16.8$$
$$= 39.8 \text{ ft.}$$

It is important that any gland leakage of air inwards be prevented in an installation of this kind, otherwise output may be reduced or stopped altogether. Pump manufacturers are generally able to decide which method of sealing is best used for a given case; nevertheless, the process of selection is often one requiring the combined attentions of both manufacturer and user. In the particular example given a conventional horizontal pump gland will not suffice; since the temperature is 120°C, the glands should be water cooled. The courses before the hypothetical pump selector are

(1) A conventional pump with outside balanced mechanical seal. Should, however, the pump be fitted with a packed gland, then its lantern ring should be connected to the pump discharge.

(2) Pump with shaft seal or gland on the delivery side of pump. (Fig. 22).

(3) Conventional pump with gland or shaft seal submerged in the fluid or some other innocuous liquid.

(4) Glandless centrifugals of the type illustrated in Figs. 15 and 16.

A sound choice in this particular case would be a pump of the latter type. However, cost considerations might well lead one to adopt another solution, such as the well-established submerged-gland type.

No special priming arrangements would be required in this arrangement. Nevertheless, the provision of a vapour separation chamber as fitted to some self-priming centrifugals would ensure ready priming and allow the pump to deal with any accidental accumulations of gases or vapours.

The choice will also be influenced by the important consideration of standardisation. If pumps of a certain type or make are already in use at the factory where the new plant is to be erected, then certain features of design may be automatically eliminated, and the range of choice narrowed. Again, shaft seals of a suitable pattern may be in use so that the same type would natually be specified for the pump in the problem.

REFERENCES
[17] Mikhail, S.: "Self-priming Pumps", *The Engineer*, 1956, **201**, 698.
[18] Johnston: "The Vertical Pump", Johnston Pump Co. Pasadena, California, 1954.

Erecting an "Alkathene" drain for the Billingham sulphuric acid plant at I.C.I. Ltd., Billingham Division factory.

PLASTICS IN THE CONSTRUCTION OF CHEMICAL PLANT

Plastics are finding ever increasing use in the process industries, particularly since the development of techniques of reinforcement

by V. E. YARSLEY, D.Sc., (Zürich), M.Sc. (Birmingham), F.R.I.C., M.I.Chem.E., F.P.I.

BEFORE embarking on a detailed consideration of the more outstanding applications of plastics, it may be helpful to take a look at the background to plastics themselves. We shall view them against the framework of industry as a whole so as to bring this relatively modern industry into correct perspective against those older established lines of production which have for long formed the hardcore of world industry.

On the basis of production tonnage we must admit that though expanding rapidly, world production of plastics is still relatively small, although actual weight is disproportionate to value, both in actual cash or in the ultimate key importance of the products. Latest statistics indicate that world production outside the U.S.S.R. in 1955 was between 2.5 and 3 million tons, with America far in the lead with 3.7 billion pounds,[1] Germany second with 425,000 tons[2] and Britain third with 330,000 tons.[3] This compares with 1949 figures for the production in America of leather 1,000,000 tons, ceramics and rubber each 1,500,000 tons, zinc and copper each 3,700,000 tons, glass 5,400,000 tons, timber 45,000,000 tons, and steel 78,000,000 tons. On the basis of specific weight (i.e. mass/unit vol.) the comparison appears less adverse, as is shown in Table I (p. 371), and still more so on the basis of cost.

Plastics by accepted definitions are organic materials which at some stage in their production are capable of flow, and which can be caused to do so by the application of heat and pressure, thereby taking up any predetermined shape. More fundamentally they are chemicals which are used mainly for their physical properties. Although it is almost a century since the pioneer plastic, celluloid, was first produced, it was only when Baekeland in the early years of this century departed from the traditional concept of organic chemistry and showed that the "in-between" products, which were neither crystalline nor liquid, could be put to advantageous use that serious attention was paid to these products of chemical synthesis. That they were used initially for more decorative applications, and in particular for the simulation of rare natural materials such as ivory, may have accounted for the fact that industry in general and engineers in particular refused for several decades to take them seriously, and the new materials were relegated to applications of relatively minor importance.

Alone among early industrial users, the electrical industry saw the possibilities of plastics in view of their excellent insulating properties which, combined with light weight and reasonable strength, made them valuable alternatives to the materials then used for this purpose, which in the main were of natural origin. It is fair to say that

[1] Chemical and Rubber Industry Report, 1956, **3** [3], 16: See also *Modern Plastics*, 1956, **33**, [3], 214.

[2] British Plastics, 1956, **29**, 1.

[3] Chem. Trade J., 1956, **138** [3594], 940.

but for the pioneer efforts of the large electrical concerns in Europe and America, plastics would never have developed as rapidly as they have done. Industry generally looked askance at plastics for many years, and indeed it needed the intensive research as much as the dire needs of World War II to give these new materials their first real chance. In the end, it was nothing more complex than a change in attitude, first on the part of industry, and then later of the using public, which ultimately made it possible to designate plastics as modern materials of construction and constructional materials in their own right. This change has been accomplished during the post-war decade, a period which has been marked, one may almost say dominated, by the development of atomic power. The coincidence of these two is of particular significance.

The Second Industrial Revolution

Industry as we know it today commenced in Britain just over two hundred years ago, when a new source of power, coal, united with a new material, iron, to usher in a period of industrial progress which has been designated by historians as the Industrial Revolution. It is a remarkable coincidence that after a lapse of almost two hundred years history should repeat itself, and in the 1950's the advent of a new source of power based on atomic fission, combined with the development of new materials of construction resulting from the joining together of complex molecules to give what we now know as plastics, should usher in a new era which some have already heralded as the Second Industrial Revolution. These may be purely artificial, or at the best empirical divisions of time and progress, and whereas the first was domestic to Britain, the second is world wide.

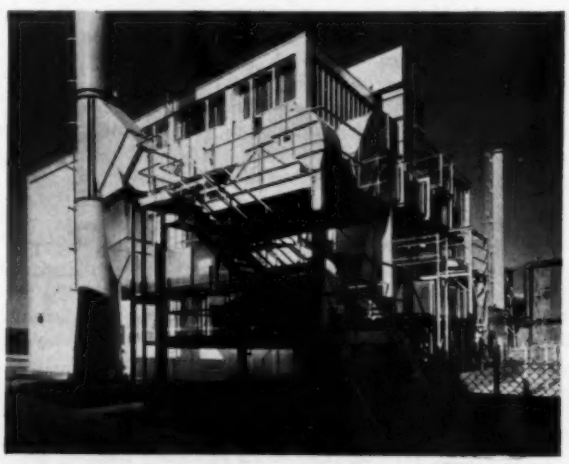
Such is the power of publicity today, that atomic fission has stolen the spotlight. The changes which result from the advent of atomic power are truly revolutionary, but it must not be forgotten that, in its constructive applications at any rate, power is of service to mankind through the medium of materials. In the days when fossilised fuels were the main source of power, the conventional naturally occurring raw materials—metals, woods and ceramics—were adequate to hold the balance, to harness or translate, as it were, available power into service for man. In an age when atomic power means virtually power unlimited, to preserve the same balance in relation to the considerable increase in human needs, materials must be available in equally increased proportion. The conventional materials are clearly limited either by time or geology. The woods we can use are limited by the forests now available and the time to replace these; the metals we need are dependent on the supplies of ore locked away, often almost inextricably, in nature's storehouse.

The synthetic materials of this Second Industrial Revolution are limited only by the supplies of simple chemicals, such as ethylene, acetylene, ammonia, alcohol or benzene, and such natural polymers as quick-growing cellulose, which could be made available to meet almost any demand. The limit indeed is only the temporary hold-up which would be necessary to multiply the chemical production units, and here in many cases plastics themselves have given direct assistance. We are approaching what an American writer recently and aptly described as a "chemistic" society, and in the ultimate this could well be one in which chemicals, in the form of plastics, might give what could virtually be materials unlimited to match the atomic-based power. This must not be taken to imply the "fade out" of conventional materials, quite the contrary. The skilful use of the new materials with the old will give increased production of consumer goods of improved quality, and these in turn could be used to improve the conditions of life of the untold millions who even today can be said to exist rather than to live.

To meet these needs it is clear that the chemical engineer has a vital role to play, since it will be his ingenuity which will make possible the polymer-producing units which may ultimately supply the needs of the thickly-populated areas of China, India or Africa. The opportunities are enormous, and it may not be so long before the almost futuristic shapes of chemical plants, such as those with which we are now familiar at oil refineries in this country, will glisten near the oil fields all over the world and which will produce the consumer products to ease the life of the most primitive peoples.

Without defining too clearly the role of the chemical engineer in industry (that was done by Professor H. E. Armstrong many years ago), it can be conceded that he has to face difficulties not encountered in any other branch of engineering. His main objective is the construction of plant in which to carry out chemical reactions economically and efficiently, and frequently under the combined application of extremes of temperature and pressure. He does not face the same type of stresses and strains as the builder of bridges, towers or skyscrapers, but he always has to face the greatest of all risks which defies calculation or predetermination—corrosion. It was for this reason that in spite of the fact that although plastics can claim little that is outstanding in tensile properties as compared with conventional metals, and since they are carbon com-

Nylon pipe, made by Richard E. DuPont Ltd., being extruded. Note absence of end plug.



An Atomic Energy Authority installation, built for the Ministry of Works by Turner & Brown Ltd., in which "Cobex" PVC ducting is used for carrying acid fumes.

Table 1. Specific Strength of Structural Materials
(Tensile strength per unit weight)

Material	Tensile Strength P.S.I.	Density		Specific Strength*
		g./c.c.	lb. ft.³	
Aluminium	30- 40,000	2.7	168.5	30,000
Brass	50-150,000	8.7	543.1	13,000
Steel	40-330,000	7.8	488	12,000
Copper	60- 70,000	7.3	455.1	17,000
Zinc	22- 30,000	7.2	448.9	8,000
Tin	4- 5,000	7.3	455.1	1,000
Lead	2,600- 3,300	11	687	600
Urea-formaldehyde	6-13,000	1.5	94	15,000
Melamine formaldehyde	7,500- 13,000	1.5	94	15,000
Phenol formaldehyde (G.P.)	6,500- 8,500	1.4	8.7	13,000
Phenol formaldehyde (asbestos filled)	8,000- 10,000	1.8	112	12,000
Methyl methacrylate	6,000- 10,000	1.2	75	15,000
Polystyrene	5,000- 10,000	1.05	65	18,000
Cellulose acetate	3,000- 6,000	1.3	82	7,000
Nylon (drawn)	100,000			
Natural silk (raw)	64,000			

* *Specific Strength = Strength per unit mass.*

pounds their ability to resist temperature is of low order, they have nevertheless earned the respect of the chemical engineer on account of their corrosion-resisting properties. In this, as in all other respects, it must be carefully pointed out that what we classify as plastics is indeed a considerable family of chemicals, mostly carbon-based, or at least having a considerable carbon content. It must necessarily follow from this that the individual plastics will show considerable variation in their ability to resist corrosion, but it can be safely said today that a plastics material is available, or can be developed, to meet reasonably all the ravages of corrosion.

Attractive as was this aspect of the possible use of plastics, it was long years before the chemical engineer would seriously consider them, and his attitude was not without justification. Trained as he had been in the use of conventional metals or ceramics, it was difficult for him to accept that materials which he had seen grow up literally before his eyes in a reaction chamber from a gas, such as ethylene, or from two simple chemicals, such as phenol and formaldehyde, could yield load-bearing members which he could use in serious construction. He was accustomed to using metals in sheet, rod, or tube form which would give him perhaps 500% safety margin on his theoretical requirements.

From the start it was clear that the demands on plastics as far as thermal resistance was concerned could never be equated, and quite logically and sensibly they were in the main ruled out for such applications. Plastics became a more attractive proposition when they became available combined with chemically-resistant reinforcing agents, and it was perhaps in the form of asbestos or the like bonded with phenol formaldehyde resins under such trade names as "Haveg" and "Keebush" that they were seriously considered by the chemical engineer. Plastics reinforced with conventional materials later became available as laminates, and these were used with some caution and to a limited degree, but it was only when it was realised that plastics could in many cases co-function with metals and ceramics, that real progress was made.

When this new approach had been consolidated on the basis of successful experience, the "all-metal" or "all-plastic" approach to constructional problems was abandoned, and the use of the new materials with the old was explored in proportion as the special properties warranted. Once the initial prejudice had been overcome, many engineers were surprised at first to find just how useful plastics could be when used as specialist materials of construction. Whilst it is by no means essential to the successful application of plastics materials for the chemical engineer to have a knowledge of the complicated chemistry which goes into their production, a working knowledge of their make up will assist him to an appreciation of their potentialities and limitations.

Irradiation of Plastics

Before proceeding to a survey of current uses of plastics, it may be helpful to take stock of what plastics can offer today, and what is likely to be forthcoming in the measurable future. The concensus of current opinion is that this is likely to be very considerable, indeed it has been suggested that whilst on the one hand the number of new polymer combinations may not be widely extended, the improvement of known types by non-chemical methods most certainly will. Already we have an indication of this in the rapidly advancing irradiation of plastics by the technique which was first suggested in this country a few years ago by Dr. A. Charlesby.

This work at first appeared mainly of academic interest, but it is rapidly progressing to very definite practical importance. It has shown that the traditional differences between the thermo-softening and thermosetting classes of plastics are to some extent artificial, and that the advantages of the latter can be "induced" in the former. This is of particular importance to the engineer who uses plastics to fabricate plant units. He can take advantage of the more easy manipulation of the thermoplastics to produce his units, which are then subjected to treatment capable of effecting changes in the physical structure of the materials, so that his finished units have the more advantageous properties usually associated with thermosetting materials.

Whilst it cannot be claimed that the chemist and the physicist responsible for the production of the plastics materials and products has yet passed out of the realm of empirical thought and procedure, considerable progress has been made in this direction; sufficient at any rate for the engineer who uses these materials to have renewed confidence in their performance. Time was when the chemist merely made the materials which he handed to the engineer to explore. Today much of this field work is done by the maker of the plastics materials, so that the user engineer can apply them with confidence. Inevitably every-day use must bring some failures; even metals with decades of stringent user trial behind them are by no means perfect.

To some extent the responsibility rests with the engineer, and the possibility of ultimate success may frequently be in direct proportion to the extent to which he takes the plastics manufacturer into his confidence, and puts before him his honest and reasonable requirements. Many cases of failure have resulted from the fact that the user asked not for what he reasonably needed, but for that extra safety cover for which he hoped but which he never really expected to obtain. It must be appreciated that plastics are not a panacea for all constructional ills. The engineer may be tempted to be more honestly frank with his plastics supplied if he remembers that plastics are by no means materials of rigidly fixed identity even within individual chemical families.

The manufacturer both of thermosets and thermoplastics has margins within which he can effect a quite remarkable variation of properties which may be manifest both in the intermediate stages of manipulation or in the finished product. It must furthermore be stressed that the ability among manufacturers to ring these changes, which are rather of structure than of chemical composition, is

Machining of natural polythene rod. (Photo: Chemical Pipe & Vessel Co. Ltd.)

The butt welding of black polythene tube. (Photo: Chemical Pipe & Vessel Co. Ltd.)

Welding of rigid PVC. In the background, 5-ft diameter PVC tubes. (Photo: Chemical Pipe & Vessel Co. Ltd.)

increasing very rapidly as knowledge of the technology of polymer formulation advances. Thus the fact that polythene or a polyester may have proved unsatisfactory for a particular application a few years ago, need not necessarily deter the user from reopening the problem today. Whereas a few years ago a small number of standard products were put out which did their best to cover a wide range of applications; today, within reason, the chemist can "tailor" a molecule the better to meet a specific application. However, there are some applications he cannot hope to meet with plastics, either alone or in combination.

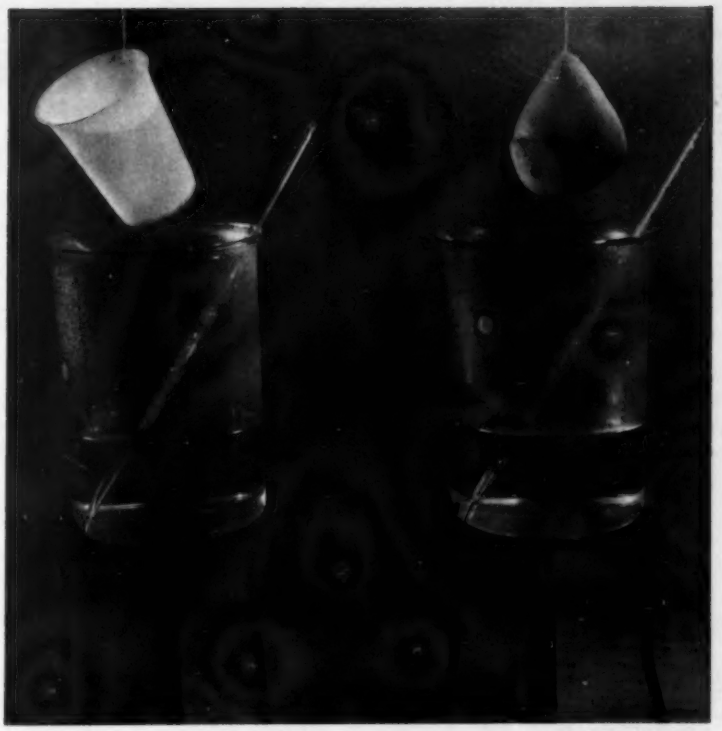
To outline the properties of even the most common of the commercial plastics is a space-consuming procedure. All the potential user needs to know are the properties and potentialities of the various classes of plastics, from which he may select a few which might reasonably meet his needs. This would bring him within the "target area", and he would then get final and specific guidance from the manufacturers of the individuals. References to current literature which may be of interest for wider reading, will be appended at the end of Part II of this article.

There is always the danger that a review of the application of any class of constructional materials in any domestic or industrial sphere may resolve itself into a mere catalogue of end-products, all interesting in themselves but of little guide to further possible uses of the materials in question. This is particularly true in the case of plastics, a term which covers many materials of widely differing properties, and has applications in almost every industrial field. Since plastics are relatively costly materials, they are never likely to offer serious replacement possibilities for the materials traditionally used for constructional work. The main role of plastics is, and is likely to develop even more so, into that of the specialist material which will enhance the performance of conventional materials.

As was pointed out recently in their very interesting survey by Creamer and Brearley,* the advances which plastics have made recently in the field of chemical engineering have been due in no small measure to the co-development in light metals and alloys, and with them has come new and improved methods of fabrication and application, which together have given a "new look" to chemical plant. With few exceptions, plastics are fundamentally carbon compounds and as such are thermally vulnerable, so that they find restriction where thermal endurance comes in question. On the other hand, they are poor conductors of heat and electricity, and as such can they offer advantageous functional combinations with metals. The possibilities of plastics as industrial constructional materials, particularly in the field of chemical engineering, lie in their selective ability to resist chemical action and so compare favourably with metals in the face of chemical industries' major enemy, corrosion.

They are, as has already been stressed, materials of considerable versatility as much in their physical as well as their chemical form. Materials of the same chemical type can be applied in a number of widely differing physical forms, a characteristic which, whilst by no means exclusive to plastics, can be capitalised with more easily than with metals. Plastics are, with some notable exceptions, available in each of the chemical types in the form of sheets, rods and tubes, which can be manipulated in much the same manner as metals or woods, as powdered masses which can be moulded, and as melts, syrups, solutions or emulsions, which can be applied in fluid or semi-fluid form.

* Lecture to 75th anniversary meeting of Society of Chemical Industry; due for publication in *Chemistry and Industry*.



The potentialities of polythene as a material of construction were increased by the development of Alkathene HD (High Density). This has better resistance to temperature, among other desirable properties (see "British Chemical Engineering", May, 1956, p. 2). This experiment illustrates how Alkathene HD can stand temperature better than ordinary Alkathene. The moulding on the left is unaffected by boiling in ethylene glycol at 110°C, whereas the moulding on the right in Alkathene 20 has completely collapsed.

Sheets, Rods and Tubes

Metals and woods, on which industry had relied for decades for constructional purposes, have conventionally been used in the form of sheets in which they are most readily available (exclusively so in the case of wood), so that it was natural that plastics should be similarly applied. The higher cost of plastics, in spite of their much lower density, made it difficult for them to compete on equal terms with metal or wood unless reinforced or supported, so that it is not surprising that plastics have been less generally applied in this form. Specially compounded laminates in which "p.f.", melamine or epoxide resins bond fabric or glass-fibre sheets, have been used in the construction of plant and machines which have to function immersed in or in contact with acid or alkaline materials, such as in parts of pulp and paper machines. Similar laminates are used in the fabrication of chutes, ducts, conveyors and perforated filter and drying trays. Here conventional methods of fabrication can be used, and individual sections bonded with a chemically-resisting cement.

More usually it is found advantageous to let metals or wood carry the load, and to use plastic sheet to provide the necessary chemical resistance. On this basis a wide range of application for plastics has been built up. Storage tanks in wood, metal or concrete are now provided with their linings of chemically-resistant plastics, such as polythene, rigid PVC or copolymers, separately tailored to fit snugly inside the supporting vessel. In cases where difficult shapes have to be provided, these are built up in polyester-bonded glass-fibres, with liners of PVC or polythene.

Plastics sheets have the advantage that in the absence of fillers they can be made available in translucent form. Transparent plastics sheets are of considerable value to the chemical as to other engineers for the protection of plant units and instruments, and generally to give vision with protection. Translucent corrugated plastics, such as the unsupported methacrylate, Perspex, or more recently glass-fibre reinforced polyester, are increasingly used for roof lighting in chemical plants.

Plastics in the form of cast or extruded rods, tubes or pipes, are finding increasingly wide use by the chemical engineer. Pipelines in metal and ceramic have long been the weak points of chemical plant, so that the light weight of plastics, combined with their chemical and impact resistance, made them attractive alternative materials. Pipelines in polythene and rigid PVC or copolymer are extruded in diameters from ¼ up to 12 or 16 in.: above this diameter they can be fabricated or "spun". Extruded pipes are available in continuous lengths; cast or spun pipes are of necessity in sections of limited length. In this way pipes of 30-36 in. diameter have been produced in polythene in lengths of 12-23 ft. Pipe sections, suitable for use in chemical plant, are also extruded in continuous lengths in "p.f." nylon, high-impact and toughened polystyrene. Polyester glass-fibre pipes are also produced continuously by weaving the glass-fibre on a mandrel to which the bonding resin is successively applied. Paper and fabric-reinforced phenolic tubes are produced in limited lengths, and these materials are, of course, basically similar to the conventional sheet laminates. Phenolic plastics incorporating fabric or asbestos reinforcement can be formed by various methods into tubes or irregular shapes, indeed complicated unions or complete plant sections can be formed in this way. It is not surprising that compositions of this nature were early explored, and have for years been well known to the chemical engineer under the trade names of "Keebush" and "Haveg", and the same principle has been more recently applied using the more chemically-resistant epoxide resins.

What may be possibly classified as an exaggerated use of the term rods is the use of exceedingly fine rods in the form of monofilaments. Chemically resistant monofilaments are today widely applied in the form of bristles for special brushes in chemical plant, and nylon, polystyrene and the vinyl chloride polymers and copolymers are used to an increasing extent in the production of chemically-resistant filter cloths.

(To be concluded)

The Law and Pollution of Water by Industrial Plants

by a BARRISTER-AT-LAW

Since the war there has been a greater awareness of the necessity of protecting Britain's water supplies, and the law is being enforced with greater diligence. In many firms the legal as well as technical problems of effluent disposal are largely the responsibility of chemical engineers, and this article has been designed to inform them of some of the more salient legal aspects of this subject.

A WRITER, in advising how to report committee proceedings, said that the perfect minute should be like water, that is to say, it should reflect what is above, reveal what is beneath and itself be colourless. It is evident that such a writer was not referring to the substance which flows, turgid and slow, in rivers and streams adjacent to modern industrial plants.

Alongside the growth of industry in the last century and a half there has been a parallel growth in the degree to which rivers have been polluted by noxious effluents. Simultaneously, there has been a growth of public consciousness of the problem which has led to the passing of Acts of Parliament (Statute Law) and a growth of private consciousness which has led to a number of actions against polluters. Such actions are normally "Common Law" actions based on nuisance.

In the case of Statute Law, there have been a number of Acts of Parliament, some of them being enacted over a century ago. Historically, the most important was the Rivers Pollution Prevention Act, 1876, under which proceedings were instituted by the sanitary authority through whose territory a polluted stream flowed. Many of these authorities were unable to proceed against industrial polluters—because they were themselves polluting the rivers! Accordingly, separate authorities were set up under the River Boards Act, 1948, and are required under the Rivers (Prevention of Pollution) Act, 1951, to prescribe standards of pollution and to enforce compliance with those standards by persons discharging effluent into rivers.

Polluters stand betwen two perils—official prosecution by River Boards, with conviction carrying heavy penalties and/or imprisonment, and Common Law civil actions in nuisance (for damages and injunction) by riparian owners farther down the river or by the owners of other rights, for example, fishery rights. (The term "riparian owner" is applied to the owner of land abutting on a river or stream.)

It may be thought that the greater of these perils is civil proceedings, because of the strictness of the Common Law criterion of pollution. That criterion has been defined on many occasions: for instance there are the words used by Lord MacNaghton in John Young & Co. *v* Bankier Distillery Co. (1893):

The law relating to the rights of riparian proprietors is well settled. A riparian proprietor is entitled to have the water of the stream, on the banks of which his property lies, flow down as it has been accustomed to flow down to his property, subject to the ordinary use of the flowing water by upper proprietors, and to such further use, if any, on their part in connection with their property as may be reasonable under the circumstances. Every riparian proprietor is thus entitled to the water of his stream, in its natural flow, without sensible diminution or increase and without sensible alteration in its character or quality.

To indicate the predicament in which a polluter is placed, it must be mentioned that, *even if a noxious effluent is so mitigated as to comply with the by-law standards of a River Board* the effluent may still constitute a Common Law nuisance.

The proof which must be provided by a riparian owner is described in *Coulson and Forbes on Waters and Land Drainage* (sixth edition):

Although it is not necessary for a riparian owner to prove actual damage to enable him to sue for the interference with his right to pure water . . . he must prove actual pollution of some character or another. . . .

The authors proceed to cite cases showing that each of the following has been held to amount to pollution:

(a) the addition of hard water to soft water;
(b) raising the temperature of the water;
(c) adding something which on meeting some other substance already in the water, each in themselves harmless, causes pollution.

The "actual pollution" which must be proved by a riparian owner means that the water of the stream must be less suitable for its native purposes. In Attorney-General *v* Cockermouth Local Board, it was held that, if for all practical purposes the water was as good as it was in its natural condition, no riparian owner can complain "merely because it is different from what it was".

The Common Law animus against pollution is so strong that cases show that an action will lie, although the water is already polluted by the acts of other persons so that no additional damage is caused by the defendant's contribution.

A Cause Célèbre

Within the scope of this article, it is only possible to consider the pollution of rivers and to concentrate on two particular cases.

The first, which was one of the outstanding pollution cases of recent years, was that of Pride of Derby & Derbyshire Angling Association Ltd., and Another *v* British Celanese Ltd., and Others (1952). The case was heard in the first instance by Mr. Justice Harman (Harman J.) and on appeal his judgment was upheld subject to a minor variation of one of his Orders. The case was of special interest because of the breadth of the issues involved and the defences put forward. The first defendant was British Celanese Ltd., the second the Derby Corporation and the third the British Electricity Authority.

They key facts were as follows. The plaintiffs were severally entitled to rights in respect of the bed, banks and water of the Rivers Derwent and Trent from below the confluence of the rivers to Borrowash Bridge on the River Derwent, about seven miles above the confluence. On

the banks of the Derwent below Derby and above the plaintiff's waters were works maintained by the defendants. Immediately after passing Derby, the river was in a reasonable pure state and supported game fish, but before reaching Borrowash Bridge, owing to the activities of the defendants, it was polluted to such an extent that it was foul and black and contained little or no fish. The pollution was caused thus:

(a) effluent consisting of sewage matter, insufficiently treated and discharged into the river from the sewage works of the second defendants, Derby Corporation;

(b) heated effluent, containing suspended organic matter, discharged into the river from the works of the first defendant, a company.

The damage and danger resulting from the pollution were aggravated by the rise in the temperature of the water caused by large quantities of heat effluent which were discharged into the river from the generating station of the third defendants, the British Electricity Authority. The water which was discharged into the river from the works of the first defendant and the electricity authority had, in each case, been extracted from the river, the extent of the first defendant's extraction being 54 million gallons of water per day and the electricity authority's extraction 120 million gallons per day.

Claims and Defences

In an action by the plaintiffs claiming, *inter alia*, (a) an injunction restraining each of the defendants from causing or permitting the pollution of the plaintiffs' waters, and (b) an injunction restraining the first defendant and the electricity authority from causing or permitting an alteration in the temperature of the plaintiffs' waters, the first defendant admitted liability, but the corporation and the electricity authority each denied liability and relied on their statutory rights and powers under private Acts of Parliament governing their operations. For example, the generating station had been set up and maintained under the powers conferred on the electricity authority's predecessor by the Derbyshire and Nottinghamshire Electric Power Acts, 1901 and 1929.

In judgment, Harman J. held that:

(i) The plaintiffs, as riparian owners, were entitled to sue in respect of the injury done to their rights in the river; as their waters had been polluted by the combined effect of the activities of the defendants, they were entitled to bring an action against all the defendants; and, even if neither the corporation nor the electricity authority had individually committed an actionable wrong, they were not relieved of liability notwithstanding that the first defendant had admitted liability and could be sued alone.

(ii) As the proviso to Section 113 of the Derby Corporation Act, 1901, expressly stated that the corporation were not authorised to construct any works or do any other thing in contravention of the Rivers Pollution Prevention Act, 1876, and as it was an offence under Section 3 of the Act of 1876 to cause any solid or liquid sewage matter to fall or flow into any stream, the corporation were not authorised by the Act of 1901 to send untreated sewage matter into the river, and, in so far as their action in doing so was a nuisance, it was forbidden by Section 109 (1) of the Act of 1901.

(iii) On the true construction of Section 37 (1) of the Derbyshire and Nottinghamshire Electric Power Act, 1929, the electricity authority were authorised to abstract water from the river only so long as they complied with the proviso to the sub-section, whereby they were directed to return the water in such a condition as not to cause injury to fish, and, as they had failed to comply with the proviso and the plaintiffs had suffered damage through their failure to do so, the plaintiffs had established a good cause of action against them.

(iv) The fact that Derby Corporation could not remedy the wrong suffered by the plaintiffs at their hands without financial asistance which they could only obtain on the authority of the Minister of Health, and that, therefore, compliance with the injunction depended on matters outside their control, was no reason for not granting an injunction against them, nor was an award of damages alone proper compensation for damage of the nature caused, since such an award would not in itself abate the nuisance and the plaintiffs would, accordingly, be left to bring one action after another for damages because of the continuance of the nuisance.

An injunction was granted against all defendants, requiring them to abate the nuisance and the injunction was suspended so as to give time to the defendants to take remedial measures. An inquiry as to the amount of damages was ordered and an apportionment of the amount between the defendants was made. On appeal, this judgment was upheld, but the severity of the injunction against the electricity authority was somewhat modified.

Notice should be taken of two observations relating to this case.

(i) In the Court of Appeal, the Master of the Rolls, Sir Raymond Evershed, in confirming the rejection of the proposition that, since all defendants were individually polluting, none could be made liable, likened the proposition to the principle "that a man armed with several umbrellas must be taken to have no umbrella at all".

(ii) In the court of first instance, Harman J., in disagreeing that the excessive heating of water by the electricity authority was inevitable, pointed out that a witness for the electricity authority admitted that the power station could be run on a closed circuit without pouring any heated water into the river; short of this, other expedients could be found, for example, the use of cooling towers which could sufficiently reduce the temperature of the water before it was returned to the river.

Cyanide in the Dee

The second important case worth citing was that of Middleton and Others *v* John Summers & Co. Ltd. (1953). The plaintiffs owned salmon fisheries in the River Dee. The defendants owned steel works which discharged effluent containing cyanide into the river and the plaintiffs complained that fish had been poisoned and the effluent prevented fish from coming up the river into their fisheries. Roxburgh J. said that the discharge was a dangerous experiment with poison; the defendants thought that the cyanide would be sufficiently diluted to be harmless, but had made an error in good faith. On discovering the nuisance, the plaintiffs took prompt action so that the cyanide-impregnated water was enclosed in a radiator and not discharged into the river. In time, the system would need cleaning and a disposal problem would arise. To prevent a recurrence of the nuisance, the plaintiffs were granted an injunction limited to cyanide and an inquiry as to damages was ordered.

For the sake of completeness, it is necessary to state that there are certain limited circumstances in which persons discharging noxious effluent into rivers can acquire a right to pollute. It is clear from what I have already said that, in the absence of such occasional rights, the Common Law criterion as to pollution is stringent. Further obligations imposed by general Statute Law on polluters require separate study and comparison with Common Law obligations.

GAS EXPLOSIONS and their prevention

by OUR SPECIAL CORRESPONDENT

Every year a hundred or so workers are severely injured by gas explosions in British factories, almost all of which could be prevented. An explosion can cause tremendous damage to capital equipment, and indeed it may wreck the whole factory. This article, by an expert on this subject, discusses the safety measures that can be taken to minimise the risk of industrial gas explosions.

BRITISH industry uses vast quantities of town's gas each year: producer gas and similar mixtures are also used in large amounts for firing furnaces, retorts and the like. Apart from the use of gases as fuels, certain inflammable gases, such as carbon monoxide, are used as "atmospheres" in some furnaces to exclude air from the work, and/or to provide a chemically active environment, as in gas carburising. Acetylene has the special property of burning with a very hot flame (being an endothermic gas), so it is consumed in large quantities for processes like welding; and it is also used for processes in which it is a primary raw material, as in the manufacture of some types of plastic.

Other inflammable gases are generated as unwanted by-products; for example, hydrogen is evolved in the manufacture of "killed spirits" by dissolving zinc in hydrochloric acid.

These, and many other examples of the occurrence of inflammable gases, will be familiar to most readers of *British Chemical Engineering*; and it is much to the credit of industry that only a hundred or so persons, not tens of thousands, are severely injured each year by gas explosions in factories in this country. But "only a hundred or so" means much in pain and suffering to the injured ones, as well as distress, and sometimes bereavement, in "only a hundred or so" families: *moreover, virtually every one of the accidents is preventable.* Not one in thousands is quite unforeseeable and necessarily inevitable.

Of far less importance, but of considerable self-evident importance nevertheless, is the loss of production and of capital equipment occasioned by these explosions. One explosion some time ago in a boiler fired by producer gas injured no one, but cost £50,000 in capital damage, and the boiler was out of action for a long time. Similar examples are legion. Thus, the prevention or mitigation of the effects of gas explosions, besides being a moral necessity, can be a profitable and worthwhile investment.

In view of the enormous amount of plant handling inflammable gases, explosions are fairly rare; and one might point to one's own factory and say that, in spite of having taken no precautions, there has been no explosion for, say, twenty years. But who knows what the twenty-first year will bring?

There is an important difference between injuries caused by explosions and those caused by, say, even obviously dangerous machines like power presses. Machinery tends to amputate fingers, hands, or even arms, but causes death only rarely: on the other hand in a relatively high proportion of cases, explosions cause death or blindness. They tend to be more severe and catastrophic than most other types of accident: and this is an added reason why special precautions should be taken, even where past experience in the given factory has not produced much evidence of trouble.

A full discussion of the whole field would need a great deal of space, so this article is limited to the problem of preventing explosions of fuel gases, such as town's gas and producer gas when used in ovens, furnaces and similar appliances.

Size *is* Important

The first question is: Which appliances need protection? An explosion, even a violent one, in a thimble could not be expected to cause much damage. But an explosion of several thousands of cubic feet of gas/air mixture can be catastrophic. One that occurred some years ago in a big conveyor oven killed two, injured eleven, blew the oven literally to pieces and wrecked the factory.

So *size* is important. In general, very few *serious* explosions occur in plant that has a free volume *of less than about* 10 *cu. ft.*

But if the thimble were always very near to a person's eyes when it exploded, it could cause blindness, which is a severe enough injury in all conscience. Therefore, plant that, by reason of its small size, might be thought to be safe, may well need protection if its position, or the way it is worked, endows it with a special risk. In this category come degreasing vats and similar plant, because trouble is twice as frequent when lighting up as compared with any other time, and the operator's hand or eye is then at the lighting hole: even a trivial "puff" under those conditions is almost certain to cause injury. Similarly, water heaters over wash-basins are at head level, and if the heater misbehaves there is a strong temptation to peer into it. But it is precisely when it misbehaves that a risk of explosion may be present: a heater that is behaving well is most unlikely to explode.

Some appliances that have a substantial volume and are not in a "safe" place have, nonetheless, a good record, because the way they operate (not necessarily the way they are operated) tends to reduce the possibility of an explosion. For example, explosions are very rare (but are still possible, and do, in fact, happen from time to time) in furnaces and kilns that work at a very high temperature for long periods without cooling. Here, if say the gas is accidentally turned off and then on again (a common cause of explosions in low-temperature plant), it relights at once without danger; whereas, in an oven that works at a temperature below the ignition temperature of the gas, such an event is extremely dangerous. Of course, it must be borne in mind that no furnace stays at a high temperature for ever, and explosions sometimes occur when one is relit "from cold" after, say, being relined.

Protection is necessary for all gas-heated equipment with the exception of plant that falls into one of these categories; that is to say, unless it is unlikely to cause injury even if it explodes, or has a history of freedom from accidents. In this connection, freedom from accident can be assessed only by those who are in a position to know what happens throughout the country: no one should attempt to assess this on the basis of the limited experience that he can gain in one factory or group of factories. The officials of the Gas Boards and H.M. Inspectors of Factories have access to the necessary information.

Finally, there is no gas-fired plant that *cannot* explode.

The Available Precautions

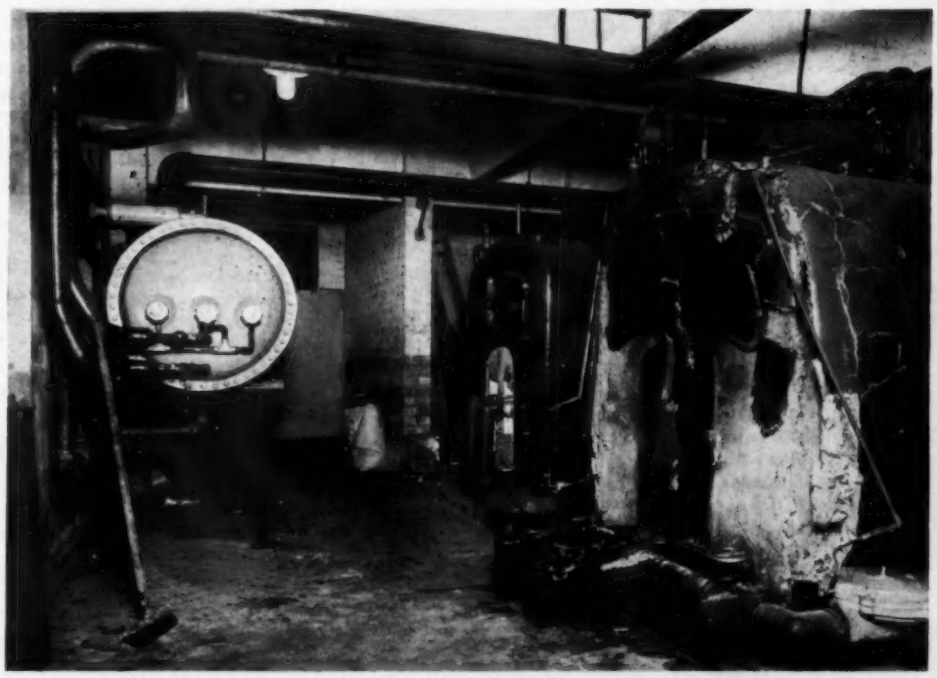
The next question is, what precautions are available? At this stage it will be convenient to give the relevant properties of town's gas. Similar information in respect of other gaseous fuels is available elsewhere (for example, in B.S. 229). A mixture of any gas or vapour (other than true explosives) with air will not burn unless it is present in sufficient quantity: this proportion is the "lower inflammable limit", or "lower explosive limit"; and, in the case of town's gas, is about 5%. Similarly, a mixture that is too rich will not burn: thus, if the proportion of town's gas in air is much above 32% the mixture does not contain enough air to burn, so 32% is the "upper inflammable limit", or "upper explosive limit", in this case. The most violently explosive concentration of town's gas in air is about 21%. which is somewhat richer than the stoichiometric mixture (18.8%). A pressure of over 110 psig has been recorded in a town's gas explosion, and this pressure was reached *only twenty-four thousandths of a second after ignition.*

It is usual in problems of safety to give, as the first precaution to be considered, the substitution of a harmless substance for the dangerous one: but, in this case, there is no reason for believing that gas is a more dangerous means of heating than any other, for all have their own risks, even if explosion does not happen to be one of them. So, therefore, this basic elementary precaution is denied to us.

Also, as will become plain, no safety device or set of safety devices can completely eliminate the explosion risk here, so we must assume that, in spite of all that we may do, an explosion will occur. Therefore, when installing new plant, it is wise, where choice exists, to choose plant that is so small that an explosion is unlikely to cause injury; or, at least, that is as small as economic and production concerns will allow. For example, a large direct-fired box-oven might have a volume of 1000 cu. ft. in which gas/air mixtures could form if something went wrong; whereas the same oven might well be heated indirectly *via* a heat exchanger of, perhaps, only 1 or 2 cu. ft. free combustion volume. Again, it might be possible to use a multiplicity of very small ovens, as is done in the process of annealing certain types of mass-produced glass article, rather than to have one large oven.

Where this cannot be done, then the plant must be able to withstand the maximum pressure that can be generated in it by an explosion. There are two ways of doing this. The appliance can be constructed as a "presure vessel" to contain the maximum explosion pressure of nearly 120 psig, suddenly applied, as is done (possibly inadvertently) in the case of, say, some combustion chambers for air-conditioning installations. Alternatively, and more usually, the possible explosion pressure may be limited to what the plant can withstand, by means of explosion reliefs—that is to say, deliberately designed weak places that will fail in an explosion, and so vent it to a safe place.

The primary requirement of an explosion relief is that it must function quickly: for example, if the relief does not function within twenty-four thousandths of a second, the explosion can have reached nearly 120 psig and died away again before the relief has had time to work. So any relief that depends on tearing, bending or fracturing a substantial member, or on any other relatively lengthy process, is all but useless. In particular, a bursting disc (which is a panel of fragile material, such as aluminium foil which has to tear to relieve the pressure) is too slow in action to relieve an explosion, even if it is barely strong enough to support its own weight, and the static pressure



This illustration shows the effects of a slow leak of gas past a valve. On lighting the central-heating boiler, the gas exploded with the results shown.

necessary to burst it may be only a few ounces per square inch. It is not unknown, where bursting discs have been fitted, for the disc's mounting to be torn out bodily when the appliance disintegrates by explosion, yet for the disc to remain intact. Suitable reliefs can take the form of doors held lightly in place by clips or by sprung ball catches, or of panels of mineral wool or compressed mineral fibre, which blow to dust under the blast. This latter feature is important in that such reliefs cannot become missiles: where the relief is a door or loose metal panel, it should be attached to a loop of chain, or be behind bars or other barriers; because, if unrestricted, it might fly for a considerable distance at high speed. This leads to the point that the relief should be in a safe place: it would be most unwise to fit a relief alongside the controls of the plant, for that is where a man is most likely to be, and he might be killed by the flame and blast, or by missiles, when the relief functions. It ought, rather, to be on top of the appliances, or at the back facing a wall, with access near it prevented.

It is most important that the area of the relief should be large enough. To quote an absurd example; if you drill a $\frac{1}{16}$-in. hole in an oven, and hope that that will relieve an explosion, you will certainly be disappointed. Conversely, if the oven is made of wire netting, even the most violent explosion will not be able to put much strain on the framework. Thus, the bigger the area of the relief the lower will be the possible pressure in the plant. In general, to keep the possible pressure down to the sort of value that ordinary ovens and the like can withstand (say, about 2 psig) a relief area of 1 sq. ft per 15 cu. ft. of volume to be protected is necessary.

It must be remembered that shelves, etc., might be an impediment to the relief of an explosion. If an oven has a perfect relief in the top, but contains a series of solid shelves, or the shelves are effectively sealed by the work on them, then an explosion near the bottom of the oven has no chance to vent itself, and, in effect, no relief has been provided. In this case it would be better to make the whole of the back of the oven an explosion relief. Moreover, there should be no external obstruction to the free functioning of the relief. For example, if there is a relief in the back of an oven, but this is pushed close against a wall, then the relief is useless: at least $1\frac{1}{2}$ to 2 ft. should be left between a relief and such an external obstruction.

Special Category Plant

Plant that has at least one long dimension is in a special category. Consider a long tunnel oven that is open at both ends: if an explosion occurs in the middle, a large volume of air has to be displaced through the ends to afford relief. Moreover, the air has to be accelerated to explosion speeds within a few thousandths of a second, or the explosion will be over and done with before the main body of the air has started to move. In effect, the air, having inertia, acts as a solid wall: it is not unknown for the side of a long conveyer oven to be blown open in spite of the proximity of an open end: indeed, the case has been quoted above where such an oven blew to pieces a few years ago. The remedy is to distribute the relief along the whole length of the oven, so that an explosion will be vented wherever it occurs. It is well to discount the open ends of long ovens as reliefs, not only for this reason but because one wishes to reduce the amount of flame and blast leaving the ends, as those are the very places where people are likely to be. A further reason for distributing the relief along the whole length of long plant is that this helps to prevent "detonation". If an explosion runs along, say, a wide pipe, it goes at its usual explosion speed for a few yards, and then it can suddenly change its character and develop an extremely high speed. An explosion in this condition is said to be a "detonation", and it is almost uncontrollably violent. Explosion reliefs at suitable intervals help to prevent the explosion from changing into a detonation: at least, they lengthen the distance that the explosion must run before it can change, and, in the case of long ovens, the aim is to increase this "run up" to a value greater than the length of the oven.

Much valuable information about explosion reliefs (and about other matters of safety with gas-fired plant) is given in the Memorandum on *Safety in Design and Operation of Gas-heated Ovens and Furnaces* (Form 1856, H.M. Stationery Office, price 1s. 6d.) and the Gas Council's *Research Communication No. GC*23 (Gas Council, and Institution of Gas Engineers, price 1s. 6d.).

Let us assume that, by the provision of suitable reliefs, we can keep the maximum pressure inside our oven down to 2 psig. This means that a force of one ton will be exerted on every 1120 sq. in (about 8 sq. ft) of the plant. It is easy to see that very large forces will be exerted on the doors of the oven: usually, the door hinges and fastenings are the weakest part of an oven (although at least one reputable maker has taken steps to remedy this) and many fatal accidents have been caused when oven doors have blown open, or have been torn off, in an explosion and have struck a man. Indeed, this is the classic cause of fatal accidents at box-ovens.

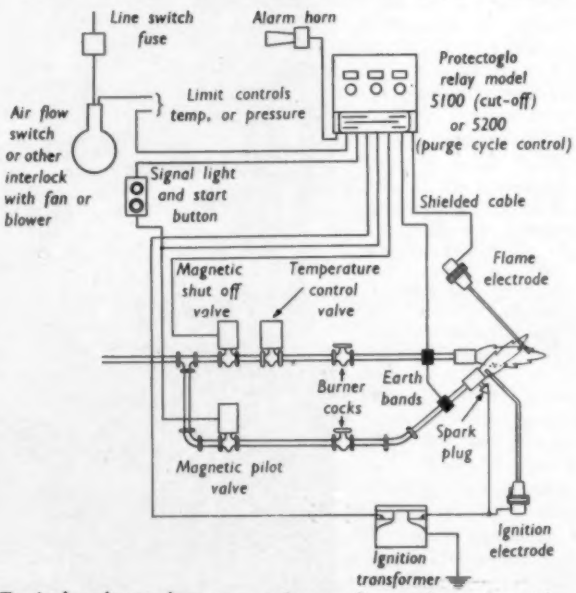
So the door fastenings and hinges must be made very strong. It should not be forgotten that an explosion might bulge an oven slightly, so any bolt that secures a door to the frame should project at least 2 in. above its hasp to allow for the hasp's rising with the bulge.

With effective explosion reliefs, and strong door fastenings and hinges, we have gone a long way towards safety.

Preventing An Explosion

We must now turn our attention to preventing an explosion; and, to do this, we must investigate how explosions can arise. This will tell us what precautions are necessary, and, regrettably, will show us that the perfect means of prevention does not exist.

Before we can have a gas explosion in our appliance



Typical safeguard system using a flame electrode with spark ignition, airflow-interlock and purge control. (Courtesy: Honeywell-Brown Ltd.)

Moderate explosion in an open-ended conveyor oven, showing how the side has been blown open in spite of the open ends.

there must be unburnt gas in it, so we must see how we can prevent unburnt gas from escaping into it. We need waste no time in discussing means of ignition of inflammable mixtures: no man can give a catalogue of all possible ways of setting off an explosion in a dangerous atmosphere: they range from the obvious, like another burner in the appliance, to the insidious, like the presence of pyrophoric deposits on the walls. In any case, it is far better not to have a bomb on the premises, than to have one and to hope that it will not be exploded.

The following are the main sources of accumulations of gas in gas-heated plant:

(1) *Delay in applying light.* Typical of this group is the case where the operator opens the burner cock and finds that his match, burning paper or taper has gone out. Enough gas flows, whilst he gets another light, to give rise to an explosion.

(2) *Main cock turned on when burner cocks were already open.* The classic case here is that where the operator turns on the burners on Monday morning, but no gas comes because it has been turned off at the main over the week-end (which is a commendable safety precaution in itself). So he goes away to open the main valve, forgetting to turn off the burners. As soon as the main valve is turned on, gas flows into the appliance via the open burner cocks; and by the time that he returns, a substantial accumulation exists.

(3) *Burner cocks not fully turned off; leaky valves; and the like.* This is self-evident. A bleed of only 5 cu. ft of gas (for example, over a week-end) from such a cause can give rise to 100 cu. ft of explosive gas/air mixture, that lacks only a light to give a substantial explosion.

(4) *Some burners lit and others not.* In this category comes also the case where, on lighting up, the flame fails to run along the whole length of a bar burner.

(5) *Flame failure.* An established flame can fail due to, for example, lack of ventilation (by obstruction of the air inlets or of the flues, or by the failure of a ventilating fan, etc.), "back-draughts" down the flue, slamming the doors of the appliance, a drop in the gas pressure (due to, say, the starting of a nearby furnace) and various other causes.

This is not an exhaustive list of possible sources of accummulations of gas in the plant, but it includes the commonest ones.

Of all these causes, No. (5) (Flame Failure) is not the most important, so it is a little surprising that the most valuable single device for preventing the occurrence of unburnt gas in an appliance should be called a "flame-failure device". The Americans, recognising this, refer to such devices as "automatic pilots": perhaps a better description would be given by some such name as "ignition monitor", because the device is designed to prevent gas from being delivered to a burner in the absence of suitable pilot flame.

There are three main types of automatic pilot in common industrial use (a fourth, the bimetallic strip, is in common use, but not on industrial plant): the thermocouple type, where the pilot flame plays on to a thermocouple that controls a valve on the gas supply; the flame electrode, which is an electronic device based on the small, but detectable, electrical conductivity of a flame; and the photoelectric cell, which is an electronic device that views the flame continuously, and truly "keeps an eye on it". Many other types are known, but these three represent at least 99% of all "flame-faiure devices' in present-day industrial use.

Where such devices are fitted, in theory unburnt gas cannot accumulate. But the theory does not correspond exactly with the truth: for example, they all rely on a valve on the gas supply; and if that valve leaks or sticks open when it ought to shut (this risk is particularly acute where, say, dirty producer gas is the fuel) then the device is brought to nought. There are other ways in which they can fail. However, the devices take away at least two-thirds of the risk that an explosion will occur; moreover, they have reached an admirable state of refinement and reliability, and can deal with most appliances, even those that have a multiplicity of burners, which might appear at first sight to be difficult to protect economically. In particular, the electronic devices are suitable for arduous conditions that would destroy a thermocouple device, and they are very flexible and lend themselves to fully automatic control of all the processes (such as purging) that are required in the appliance.

This is not the place to go into details about "flame-failure devices": the makers are always willing to give very full information to potential customers.

Precautionary Devices

They should be backed up with such other devices as may be appropriate; in particular the following:

(i) In the case of bar burners, a "spreader plate" (that is, an inverted angle- or channel-iron over the burner) ought to be fitted to help the flame to run along the whole length of the bar, and to prevent drips of paint or dirt from the work, etc., from falling on to the bar and perhaps clogging it.

(ii) A down-draught diverter is necessary on the flue, so that a back-draught from the chimney is less likely to blow the flame out or to interfere with the combustion.

(iii) Where there are dampers in the flue or air inlets, stops should be fitted, or the damper should be cut away, such that at least one-third of the flue is always open. If this is undesirable for any reason (as is the case on certain high-temperature furnaces), then the damper ought to be interlocked mechanically with a gas valve to ensure that the gas cannot be turned on whilst the damper is shut. Here it might be as well to mention the obvious point that the flues should be of adequate size: as a "rule of thumb" guide, 1 sq. in. of flue is necessary per 15 cfh of gas supplied to the appliance, with a minimum size of flue of, say, 4 in. diameter for industrial equipment.

(iv) Where fans are fitted, they ought to be interlocked

with the gas supply such that a failure of the ventilation shuts off the gas. This is best done by flow switches and the like, rather than by electrical means on the fan motor alone, because failure of the ventilation can be caused by more than purely electrical faults. For example, the fan belt, or the key that joins the rotor to the spindle, might break, or the flue may be obstructed by something not related in the least to the fan itself: explosions from such causes are by no means unknown.

(v) Special combusiton systems need their own special precautions. For example, flame arresters are necessary with inflammable "premix" gas/air mixtures, which are used in certain burners: and non-return valves are necessary on both the gas and the air supplies (they are a legal requirement under the Gas Act for a town's gas supply) in all cases when air under pressure is added to the gas before it reaches the burner.

(vi) It is good practice, from the point of view of safety, to fit a governor to each appliance. This reduces the possible sudden drop in gas pressure when adjacent plant starts up.

(vii) Where "flame-failure devices" are impracticable, a low-pressure cut-off valve should be fitted. This valve will not allow gas to flow, when the pressure in the supply has dropped, until all cocks downstream of the valve have been closed fully. Thus protection is given against the conditions described in Cause (2) above, and against some of those in Cause (5): in fact, it reduces the risk of having an explosion by about one-third.

Points Worthy of Mention

Finally, the following points are well worth attention, whatever the appliance:

(i) The operator should be competent. Gas appliances are often simple to use, but that is no reason for thinking that no training or skill is necessary in their use. If the operator is not reliable, or not fully conversant with his plant, then he might well cause danger, in spite of the most elaborate safety devices. His instructions should be clear, simple and precise; they should be in writing and should at least state exactly how the appliance should be started and shut-down.

(ii) The means of lighting should be suitable. It is all too common to find that the operator turns on the burner cocks of a large furnace, throws in some burning oily waste, and runs.

(iii) Where possible, the appliance should be lit with its doors open. In any case, where mechanical ventilation is provided the appliance should be purged for a few minutes before any attempt is made to light up. A purge of six times the volume of the appliance is usually more than adequate to dilute any gas that may be present to below its lower explosive limit: automatic purge timing and measuring devices are often incorporated into the ignition sequence control of electronic pilots.

(iv) All equipment needs maintenance and testing. Gas valves and controls, and the supply pipes, etc., should be examined fairly frequently (six months is not an unreasonable period in most cases, but the interval might have to be reduced to a few days if the gas is particularly dirty) and serviced as necessary. If dirty gas is being used, whereby there is a risk that valves will stick open when they ought to close, either it ought to be cleaned before entering the supply or powerful driven valves should be used. It is a good plan to test the safety devices (for example, by turning off the gas for a moment, and then turning it on again) once a day. The safety devices should not be used as a routine measure for shutting down at the end of the day.

(v) The control system should be so designed that any foreseeable failure does not lead to danger. For example, if the gas is so dirty that valves driven by compressed air must be used, then they should be of the type where the compressed air holds the valve open against a heavy weight, so that a failure of the air results in closure of the valve.

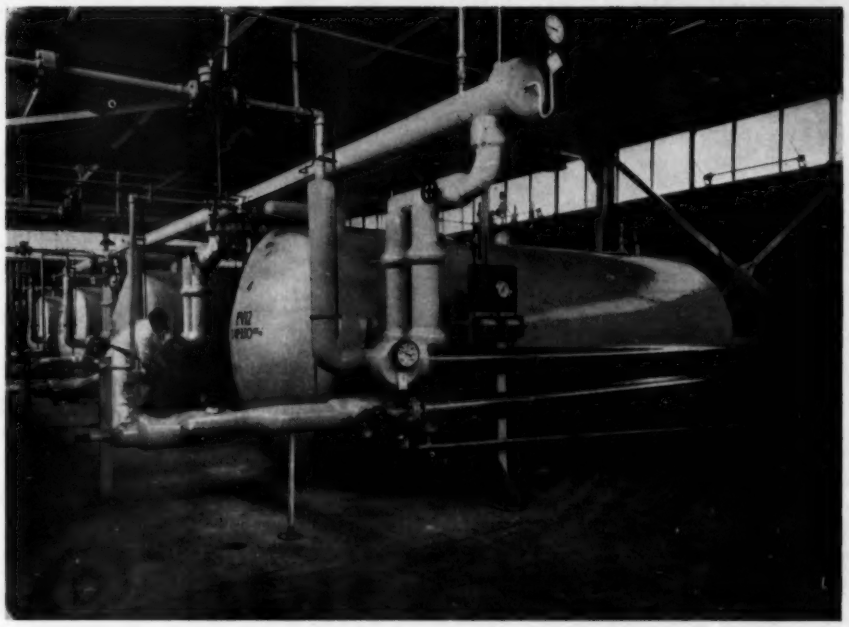
Gas is a good and powerful servant, but it can wreak havoc if it gets out of control. There is no reason why this should happen, and this article will have fulfilled its purpose if it has drawn attention to the fact that quite common and practicable safety devices and measures exist to give a standard of safety that other problems, such as road traffic, do not know.

The Mechanisms of Tablet-making

THE popularity of the tablet as a form in which to give and take medicine has increased enormously during recent years, yet the mechanisms by which a mass of powder is compressed into a compact are by no means fully understood. A paper which should help towards a better appreciation of the theory of tableting was read to the British Pharmaceutical Conference in Dublin last month by David Train, of the Imperial College of Science and Technology and the School of Pharmacy, University of London. Some of the theories, often conflicting, that had been advanced to explain the mechanism of pressing were based on the behaviour of metals and would not necessarily hold when applied to non-metals, he suggested. In his work, therefore, compacts were prepared from a suitable non-metal, heavy magnesium carbonate, B.P., under controlled conditions, partly to obtain additional evidence on the sequence of events in compaction and partly to provide information for use in further work.

A horizontal split die was designed in which there were eight sections each of 2.5 cm. depth which permitted a maximum fill of 13.5 cm. An accurate location was achieved by an overlapping skirt having a taper of 3 degrees on the lower edge of each segment. This engaged on a corresponding taper on the upper edge of the lower segment to give an exact fit. A die-set was used between the platens of a 50-ton hydraulic press to give a maximum punch pressure of over 2000 kg/sq. cm. So that different powder layers could be distinguished in the compact, 0.25% ammoniated carmine was used to produce a powder of satisfactory colour to contrast with the natural white colour of the material. Three levels of pressure, three depths of powder and two surface conditions—unlubricated and lubricated with colloidal graphite—were used.

On examining sections of the resulting compacts, the striking observations noted included not only differences in relative displacement of the layers of material when the unlubricated and the lubricated surfaces were used, but also the presence of two typical kinds of crack. The relation between the relative volume of the material and the applied pressure was determined for selected conditions of pressing and, as a result of estimating variations in relative density within a compact, the author was able to put forward a tentative explanation of the cause of the troublesome phenomenon in tablet-making, capping.



Storage tanks for liquid carbon dioxide at Calder Hall, showing the four specially designed tubular evaporators. Each of these units can vaporise more than two tons of carbon dioxide an hour. Total output is over eight tons an hour when the main circuit is being filled or purged.

Carbon Dioxide at Calder Hall

The Largest Single Installation in Britain

COOLING of the graphite-moderated reactor at the Calder Hall power station and the transfer of heat from the reactor to the steam-raising plant is achieved by forced circulation of pure carbon dioxide gas at moderate pressure in a closed circuit through the reactor and the steam-generating heat exchangers. The total amount of carbon dioxide in the system is considerable, and the supply of gas, both for the initial filling and for normal operation, presented a number of special problems.

Large-scale uses for carbon dioxide already exist in the bottled-drinks industry and many industrial fields. The total usage at Calder Hall necessitates considerable reserves on site, and the only satisfactory method of supply which meets all the requirements is bulk delivery and bulk storage of liquid carbon dioxide, introduced into this country in 1949 by the Carbon Dioxide Co., a division of the Distillers Co. Ltd.

The installation at Calder Hall, supplied and erected by the company, is the largest single installation so far in action in the British Isles. It consists of four specially insulated steel tanks, in which a total of 22 tons of liquid carbon dioxide may be stored. Each tank is fitted with an automatic pressure-controlled refrigerator, which cools the liquid to about 0°F and maintains the pressure at 300 psi.

The storage tanks are filled by bulk deliveries in the companys standard road tankers, which carry four tons of liquid at sub-zero temperatures under pressure. The vehicles are filled at one of the many factories of the Carbon Dioxide Co. situated throughout the country, and are discharged at Calder Hall by means of an electrically-driven transfer pump on the vehicle. This pump is powered by a generator coupled to the tractor engine. Filling or emptying a tanker takes about one hour and is carried out without interrupting normal working of the plant.

For use in the reactor circuit, the liquid carbon dioxide is vaporised in four specially designed evaporators, developed and constructed by the D.C.L. Research and Development Department in conjunction with the engineers of the Atomic Energy Authority. The evaporators consist of two parallel banks of steam-jacketed tubes, the number and size of which were calculated to meet the maximum demand of the system. Each unit can vaporise more than two tons of carbon dioxide an hour. The units are coupled to a manifold, giving a total output of over eight tons an hour when the main circuit is being filled or purged. The same system supplies the smaller quantity of carbon dioxide gas required for normal operation.

Constant control is exercised during manufacture of the carbon dioxide, and the system of bulk delivery and bulk storage ensures that there is no loss of quality before the very pure gas is fed into the reactor system.

The greater part of the installation consists of standard equipment whose efficiency has already been established in general use. The special modifications in design and material required to meet certain unusual features in the Calder Hall specification have proved very satisfactory under test and have made the system completely reliable in this latest application.

Studs welded to framework of gas-separation plant for the fixing of aluminium panels. The generating plant operates at −196°C, the temperature being maintained by filling the space between the plant and panels with powder insulation. The panels are bedded down on strips of rubber to ensure an air-tight seal. (Photo: Petrochemicals Ltd.)

STUD WELDING FOR THE FABRICATION OF CHEMICAL PLANT

Increasing use is being made of stud welding for fabrication purposes in chemical and oil plant, but the advantages of the process have not yet been fully exploited in Great Britain

BASICALLY, stud welding is an electrically-controlled method of welding ferrous and non-ferrous attachments to components and structures, and the process employed resembles arc welding, in that a weld is made by drawing a heavy current arc between the attachment and the parent metal.

The speed of the process is appreciable and the saving in man-hours in jobs requiring the fixing of hundreds of studs is considerable when compared with, say, drilling and tapping methods. The result is strong, and the technique is of special value when other methods of fixing are impracticable or uneconomical; for example, when it is necessary to operate from one side of a workpiece only. An important advantage is the avoidance of any need to perforate or even to weaken the parent structure. A stud weld barely has any effect on the parent metal and does not introduce a weak spot susceptible to liquid or gas leakage and corrosion.

The equipment for stud welding consists essentially of a hand tool, a controller and power source. A British manufacturer's equipment is described as follows: "The two main items of equipment necessary for stud welding are a light-weight hand-tool—some versions of which can be suitably mounted for jig-assembly, repetition work—and a portable controller. These are conected together to a power-source by cables. Energising of a solenoid contained within the hand-tool withdraws the attachment from the workpiece to strike the arc. The controller, suitably adjusted, automatically times the weld cycle, and when the solenoid is de-energised, the attachment is plunged into the molten weld metal where it remains secured. Use of the equipment requires very little skill, the operator merely has to insert an attachment in the tool, place a porcelain ferrule round the attachment (the purpose of the ferrule is to eliminate atmospheric contamination and to produce a neatly shaped weld), locate the tool on the workpiece and press the trigger."

Chemical Engineering Applications for Stud Welding

In chemical and oil engineering, useful applications of stud welding may be made where insulation or a refractory material has to be attached to structures. A wide range of studs has been developed for these uses, made of mild steel, low-alloy steel, stainlesss steel or aluminium, brass, Monel, etc., to suit the conditions to be encountered. Studs of austenitic stainless steel and of low-alloy, high-tensile steel may be welded easily. Studs made of a low-alloy, high-tensile steel are also easily welded, these studs being suitable for many applications where tensile strength and resistance to fatigue or heat are essential.

Commonly employed types of stud for insulation-fixing are plain studs or pins, the studs being used for board insulations which are drilled; placed over the welded studs and held down by washers and nuts. The pins are generally used for soft insulating materials which are impaled on the welded pins and secured by clips. For

light insulation, split pins are sometimes used, and for heavier materials, slotted studs can be employed which, after welding, can be opened out like split pins. Special studs must sometimes be employed; for example, plate-headed studs have been produced to anchor the wire meshing or reinforcement bars for Gunite, concrete and other heavy refractory insulation. The metal reinforcement for the insulation is arc welded to the plate head, which is itself stud welded to the stud. For fixing metal laths and wire, frequent use has been made of hook-shaped studs which can be employed for hooking or encircling the wire.

An example of where the use of the process avoided expense was in the manufacture of a dewaxing drum for a refinery installation. The design required drums of 10 ft diameter varying in length from 16 to 20 ft; on these, screening had to be mounted externally to collect wax as the petroleum-filled drums rotated. The engineers decided to support the screen on studs, all of the same height and evenly dispersed around the cylinder's circumference and along its length. A cradle was arranged to run on rails adjacent to the cylinder so that the studs could be precision-welded in a line along the length of the cylinder, spaced at intervals of 3¼ in. One row having been completed, the cylinder was rotated on its axis so that the next row of studs could be welded. Between six and seven thousand studs were needed.

Process Saves Time and Money

In lining the inside-wall of a viscosity breaker secondary flash tower with 14-gauge stainless steel sheet, an estimated 50% saving in time and cost was achieved as compared with the alternative conventional hand-method. The sheets were appropriately punched before being placed in position, and were then secured to the tank by welding special stainless steel studs through the holes, so that the studs were completely fused with the lining and the tank wall. In such a "plug welding" process a spot weld through a fairly thin sheet of metal is produced, in effect. For drip-welding, "break-off" studs have been developed which have a neck thin enough for the unwanted portion of the stud to fall away when the heat due to the heavy welding current melts the stud neck. The welding end of the stud is small enough to melt during the arcing period, so forming a neat plug weld of metal which secures the top sheet of metal to the bottom sheet.

Typical of many instances of maintenance work for which stud welding facilities can be of immense assistance to plant engineers is the case of an oil refinery chimney stack in which an ¼-in. thick perforated steel lining tended to become detached from the wall of refractory bricks that it lined. The damage was caused by unforeseen currents in the gas flow, and was repaired when the plant was shut-down by reinforcing the lining with studs. The repair was executed by drilling holes through the brickwork so that with a stud welding hand-tool having a longer than usual chuck, studs could be welded to the inside of the outer wall of the stack. To prevent the corrosive gases from penetrating beneath the brickwork, tubes were placed round the studs, and these, like the lining, were held in place by washers and nuts run down on the studs.

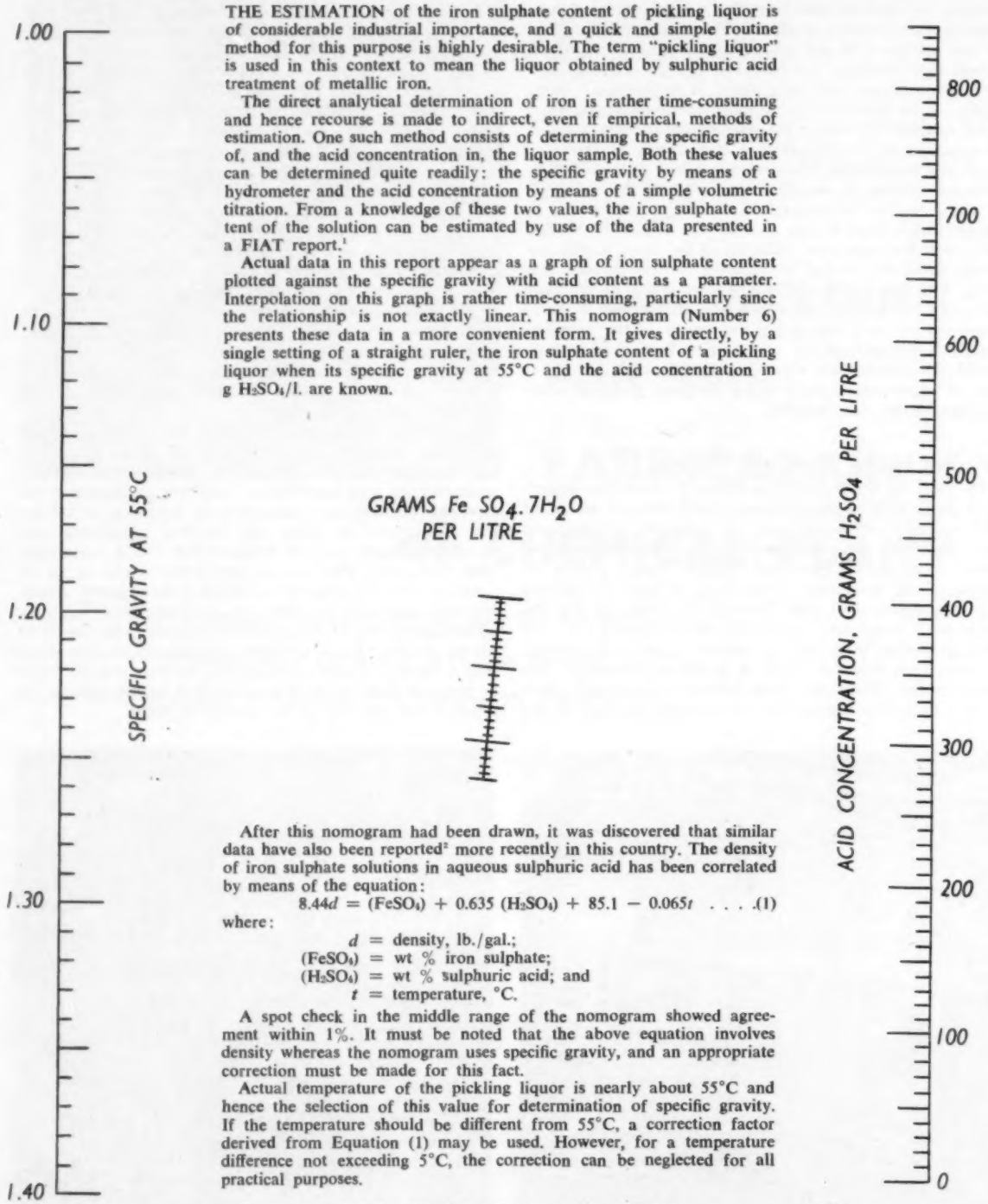
Stud welding has also been used successfully in the construction of hoppers and pulverisers; of heat exchangers and solvent extractors; in the hanging or mounting of pipes and cables; in the attachment of manhole covers to chemical tanks; in bubble-cup tray distillation plant; and air filters.

Some of the more common uses of stud welding in constructional work are in the fixing of corrugated steel, aluminium or asbestos to purlins, staunchions, etc.; the anchoring of steel members to concrete or masonry; the servicing of fireproof insulations or masonry claddings; the attachment of pipes for heating, ventilating and sprinkler systems; and the fixing of steel treads, hand-rails, steel floors, etc. This list of applications could easily be extended, but the important point that the engineer should bear in mind is that there is enormous scope for the advantageous use of stud welding in many large industrial plants, whether the immediate requirements be concerned with a small job, such as fixing identification tags or plates to pipes, or with a major project, such as the securing of heavy metal sheeting to gas-separation plant.

A stainless steel, continuous counter-current solvent extractor on which stud welding was used to hold the cover plates and bearing housings, to secure the port-holes and to fasten the drive covers. (Photo: Crompton Parkinson Ltd.)

Partially destroyed insulation of an oil refinery catalytic cracker furnace, illustrating that, despite the onerous service conditions, stainless steel plate-headed studs were virtually unaffected. (Photo: Crompton Parkinson Ltd.)

For Quick Estimation of Iron Sulphate Content of Pickling Liquor



THE ESTIMATION of the iron sulphate content of pickling liquor is of considerable industrial importance, and a quick and simple routine method for this purpose is highly desirable. The term "pickling liquor" is used in this context to mean the liquor obtained by sulphuric acid treatment of metallic iron.

The direct analytical determination of iron is rather time-consuming and hence recourse is made to indirect, even if empirical, methods of estimation. One such method consists of determining the specific gravity of, and the acid concentration in, the liquor sample. Both these values can be determined quite readily: the specific gravity by means of a hydrometer and the acid concentration by means of a simple volumetric titration. From a knowledge of these two values, the iron sulphate content of the solution can be estimated by use of the data presented in a FIAT report.[1]

Actual data in this report appear as a graph of ion sulphate content plotted against the specific gravity with acid content as a parameter. Interpolation on this graph is rather time-consuming, particularly since the relationship is not exactly linear. This nomogram (Number 6) presents these data in a more convenient form. It gives directly, by a single setting of a straight ruler, the iron sulphate content of a pickling liquor when its specific gravity at 55°C and the acid concentration in g H_2SO_4/l. are known.

After this nomogram had been drawn, it was discovered that similar data have also been reported[2] more recently in this country. The density of iron sulphate solutions in aqueous sulphuric acid has been correlated by means of the equation:

$$8.44d = (FeSO_4) + 0.635\,(H_2SO_4) + 85.1 - 0.065t \quad \ldots (1)$$

where:

d = density, lb./gal.;
$(FeSO_4)$ = wt % iron sulphate;
(H_2SO_4) = wt % sulphuric acid; and
t = temperature, °C.

A spot check in the middle range of the nomogram showed agreement within 1%. It must be noted that the above equation involves density whereas the nomogram uses specific gravity, and an appropriate correction must be made for this fact.

Actual temperature of the pickling liquor is nearly about 55°C and hence the selection of this value for determination of specific gravity. If the temperature should be different from 55°C, a correction factor derived from Equation (1) may be used. However, for a temperature difference not exceeding 5°C, the correction can be neglected for all practical purposes.

O. P. Kharbanda, D.Ch.E., A.M.I.Chem.E.

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[1] FIAT 1117: "Treatment of Spent Pickling Liquors Containing Sulphuric Acid and Iron Sulphate". British Intelligence Objective Sub-Committee, H.M.S.O., London, 1947.

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Synthetic Rubber

by Dr. Lincoln T. Work

IN the same way as many natural products, rubber has fluctuated greatly in price in response to market changes. During the last nine months it has moved from 29 cents a pound to 56 cents; the price is now around 35 cents. As natural rubber has to be shipped over long distances, crude rubber prices are much affected by international crises. This has happened, for instance, during the Suez crisis. It is no easy matter to equate supply and demand, as it takes seven years to bring new trees into production. The quest of several decades, accelerated by the war, has brought into use a number of synthetic rubbers, chief of which is GR-S, which has a stable price of about 23 cents. Much of this synthetic rubber development has been sponsored by the U.S. Government, the prime producer until a year or so ago, when it turned over most of its capacity to private industry. Already a new burst of effort has occurred which should result in substantially increased production. The present plant capacity of just over one million tons will be increased by 50% inside two years. The synthetic rubber industry is largely located in the East, from Connecticut to the Ohio Valley to Michigan; in the west in California; and in the south in Texas and Louisiana. However, present indications would seem to emphasise that it is in the latter area that the greatest expansion of the industry can be expected.

Future Production Plans

Synthetic rubber is closely connected with the petroleum industry and there are several combinations of rubber and petroleum companies now actively engaged in its manufacture. This also accounts for the three major locations which are referred to above. The 1955 and 1957 capacities may be compared by company and by type of rubber.

By Company

Producer	*1955 Capacity**	*1957 Capacity**
Firestone Tyre & Rubber	130.0	230.0
Goodrich-Gulf Chemicals	212.0	222.0
Goodyear Tyre & Rubber	115.2	192.0
E. I. Du Pont	100.0	125.0
Texas-U.S. Chemical ...	88.0	111.6
Shell Chemical	89.0	110.0
Phillips Chemical ...	63.0	108.0
Copolymer Rubber & Chemical	49.0	69.0
American Synthetic Rubber	44.0	68.5
Esso Standard Oil ...	47.0	47.0
Humble Oil & Refining ...	43.0	44.5
United Carbon	44.0	44.0
General Tyre & Rubber ...	0.0	40.0
U.S. Rubber	22.2	30.0
Nitrile Rubber Makers ...	50.0	66.0
TOTAL	1,096.4	1,507.6

* Capacity figures are in thousands of long tons

By Type of Rubber

Type	*1955*	*1957*
GRS	856,400 tons	1,255,100 tons
Butyl	90,000 tons	91,500 tons
Neoprene	100,000 tons	125,000 tons
N-type	50,000 tons	66,000 tons

Some Recent Applications

GRS is a general-purpose rubber-synthetic, and it is used in automobile tyres. Butyl rubber is used in inner tubes and has been made by Humble Oil & Refining and by Esso Standard Oil. Because of the advent of the tubeless tyre, demand for this rubber has not increased and may diminish.

An announcement by Esso Research & Engineering Co. on September 18 indicates that an all-butyl car tyre has been developed by Esso. The announcement, which was made at a Press conference, indicated that a pilot-plant product of this type would be test marketed in six months. It is not known when commercial development and marketing of the tyres would take place. Some of the advantages claimed in this announcement were immunity to atmospheric or chemical attacks which would cause other rubbers to crack, smoother riding qualities, and low noise level. These tyres are said not to "squeal" on rounding corners. It is also stated that the all-butyl tyres stop much quicker than GRS and natural rubber tyres on both wet and dry pavements. The key to this development lies in the perfection of butyl latex which does permit the bonding of butyl rubber with tyre cord on existing plant equipment. On the same day Firestone Tyre & Rubber Co. announced that Army Ordnance had completed tests on military truck tyres made of a new material called Coral, a synthetic rubber developed by them which has the basic properties of natural rubber. These recent announcements show that the field is in transition and, currently, unexpected changes may take place at any time.

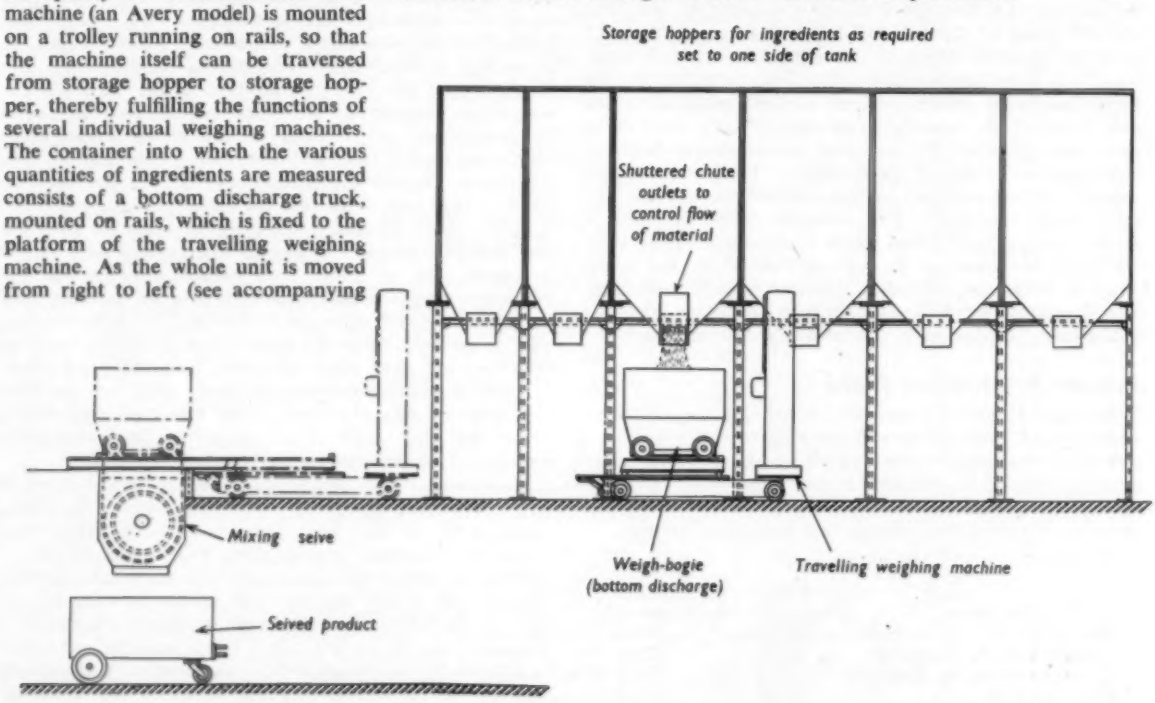
Neoprene is the chlorinated product from acetylene which has been produced by the Du Pont Co. Being resistant to oil and heat, it is used in gasoline hose. Nitrile or N-rubber is a specialty type, made by several companies, which has good heat and oil resistance. The location of plants making this rubber is spread over several points. The comparatively stable price structure is important to the nearly 1000 manufacturers of rubber products who depend upon this raw material. It is versatile and can be tailored to meet the needs of the consumer. As the demand rises, productive capacity can be developed to ensure its availability.

What, then, is the place of natural rubber? Even as little ago as 1948, natural rubber served about 60% of our market. Last year it was a little over 40%, and the predictions for 1960 give it between 25 and 35%. Concurrent with this, there is a rapidly growing demand for rubber in other parts of the world. Only a small amount of this will be synthetic. In the ten years since 1947, the growth of this market may prove to be about a million tons. While the tendency to increase the production of natural rubber may be limited to planting higher yield rubber trees, the next few years suggests no critical break in consumption of the present supply. In fact, synthetic rubber may prove to be the blessing that has prevented a critical shortage of rubber. President Eisenhower's recent report on the nation's rubber requirements and resources says, "Broadly, the picture shows a certainty of increased world dependence on synthetic rubber for the next ten years".

PROCESS ENGINEER'S NOTEBOOK

Combined Batching, Weighing and Sieving Plant

AMONG A NUMBER of interesting equipment arrangements and devices which were noted during a visit to the Ardeer factory of the I.C.I. Nobel Division was the use of a single dial weighing machine which avoids a multiplicity of such machines. This machine (an Avery model) is mounted on a trolley running on rails, so that the machine itself can be traversed from storage hopper to storage hopper, thereby fulfilling the functions of several individual weighing machines. The container into which the various quantities of ingredients are measured consists of a bottom discharge truck, mounted on rails, which is fixed to the platform of the travelling weighing machine. As the whole unit is moved from right to left (see accompanying diagram), so the quantities of ingredients are added till the unit reaches the end of its travel on the left. Thereafter the bottom-discharge truck is carried forward over the sieve which acts as a combined safeguard for the extraction of foreign materials and also as a preliminary mixer. The basic principles of this arrangement have many varied applications, and can be adopted and modified to suit the particular requirements of any situation where the system may be found to be practicable.

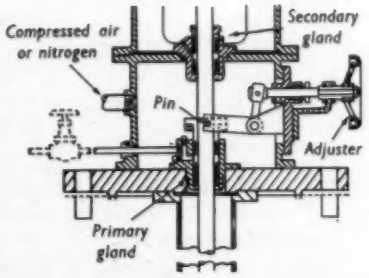

Storage hoppers for ingredients as required set to one side of tank
Shuttered chute outlets to control flow of material
Mixing seive
Weigh-bogie (bottom discharge)
Travelling weighing machine
Seived product

Sealing an Agitator or Submersible Pump Shaft on a Closed Vessel

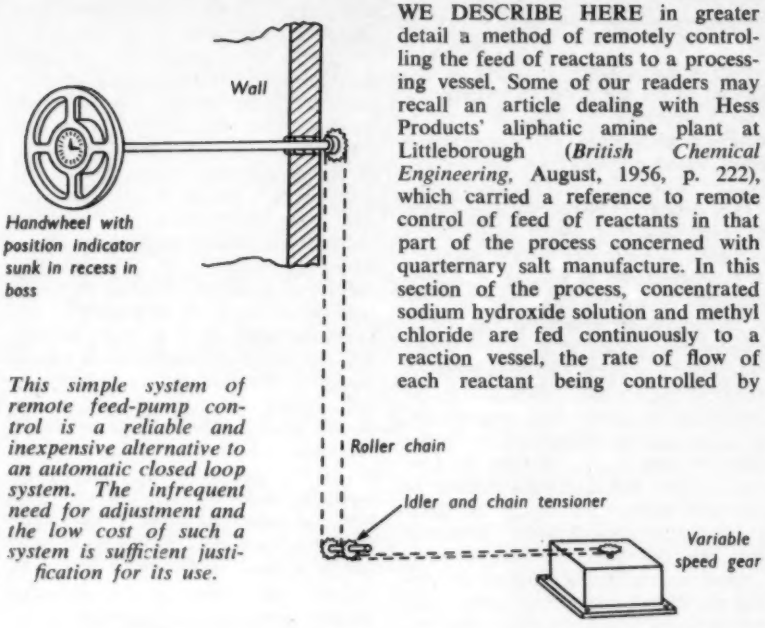
IN PRINCIPLE the method consists of enclosing the main gland and subjecting the enclosure to a pressure of air, carbon dioxide or nitrogen, depending upon the materials in the containing vessel. The pressure of the atmosphere in the enclosure should be slightly in excess of the normal working pressure in the vessel.

If the gland employed at the point where the shaft passes through the cover of the vessel is of the conventional packed type, then, since it is enclosed, some means of adjustment must be provided. Where a detachable inspection cover is objectionable, on the grounds of hazard, or where the repeated making and breaking of joints interrupts the process, a remote means of adjustment must be available.

A satisfactory method of carrying out this adjustment is shown in the accompanying figure. In this mechanism a threaded spindle is rotated by means of a hand-wheel and its lateral movement applied to an arm attached at right angles to a pivoted fork. The ends of this fork are slotted to engage with two pins on the gland follower, so that movement of the spindle inwards causes a downwards tightening movement of the gland follower. Additional glands are provided for the agitator (or pump) shaft at the point where the shaft emerges from the enclosure, and where the gland-adjusting spindle passes through it.



Remote Control of Pump Feeding into Processing Vessels



This simple system of remote feed-pump control is a reliable and inexpensive alternative to an automatic closed loop system. The infrequent need for adjustment and the low cost of such a system is sufficient justification for its use.

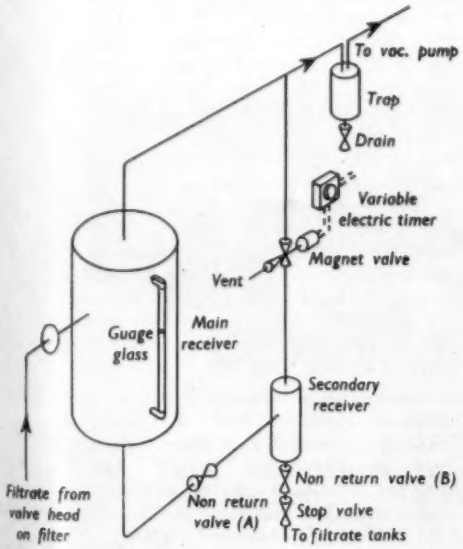
WE DESCRIBE HERE in greater detail a method of remotely controlling the feed of reactants to a processing vessel. Some of our readers may recall an article dealing with Hess Products' aliphatic amine plant at Littleborough (*British Chemical Engineering*, August, 1956, p. 222), which carried a reference to remote control of feed of reactants in that part of the process concerned with quarternary salt manufacture. In this section of the process, concentrated sodium hydroxide solution and methyl chloride are fed continuously to a reaction vessel, the rate of flow of each reactant being controlled by variation of the feed pump rpm. The latter is, in each case, a small reciprocating pump.

In the arrangement of the plant the feed pump and variable-speed gear are situated in the open, whereas the reaction vessel is under cover and separated from the pumping equipment by a wall. It was realised that the plant operators would be more able to control the plant if flow control of the reactants could be carried out from a position inside the building from which the other instruments concerned with the control of the process—temperature and pressure-indicator recorders—could be viewed.

The accompanying figure shows how the speed control of a feed pump is remotely controlled from a position close to the reactors. With each operating hand-wheel, an integral dial position indicator is provided which shows the exact position of the speed varying wheel on the gearbox. Accurate variation of either one or other of the two flows is thus possible.

Vacuum Filtration without the need for a Filtrate Pump

WHEN A SMALL-SCALE vacuum filtration plant is required, its designer may find reasons for dispensing with a filtrate pump. For example, the filtrate may have physical or chemical properties which make gland sealing difficult, or the quantities to be dealt with may be inconveniently small for a pump of normal design. The accompanying diagram shows one way of doing without a filtrate pump: In this arrangement two filtrate receivers are provided, a primary receiver and a much smaller secondary one which really replaces the filtrate pump.



This latter receiver is alternately avacuated and vented to atmosphere. This enables the secondary receiver to be alternately charged and then discharged as desired. The period of time elapsing between charge and discharge of the secondary receiver may be varied by adjustment of the timer controlling the operation of the magnetic three-way valve.

If the plant requires the liquid to be elevated, the vent connection of the three-way valve may be connected to low-pressure air at sufficient pressure to give the desired amount of lift. In this case the designer must, of course, be sure that the additional air volume to be dealt with by the vacuum pump will not upset the vacuum conditions and give too wet a cake.

The time is set so that the outflow from the secondary receiver is slightly greater than the flow of filtrate into the main receiver. A glass secondary receiver is therefore an advantage, since it permits viewing of the liquid movement at the discharge end.

Level Controller used as a Vacuum Controller

THIS TIP MAY PROVE useful to the engineer who finds himself in need, at short notice, of a vacuum controller and who has at his disposal a liquid-level controller of the float-operated type. The adaptation described is best carried out on plants situated above ground level.

The upper connection of the float-chamber-transmitter is connected to the vessel to be maintained under vacuum. The lower opening is connected by means of narrow-bore piping to a small open tank so that the difference in liquid levels established under vacuum corresponds to the actual vacuum that is desired.

Fluctuation of the vacuum thus brings about a change of liquid level in the float chamber and, as a result, the movement of the float causes a corrective action to be applied to the system. For example, too great a vacuum will be reflected in a rise in liquid level in the float chamber, and upward movement of the float is therefore arranged to lead to a wider opening of the valve controlling the air bleed into the system, so that the vacuum is reduced to the value that is desired by the engineer.

Book Reviews

Production of Heavy Water—National Nuclear Energy—Series Division III, Volume 4F

Edited by G. M. Murphy
McGraw-Hill, New York and London, 1956.
Vol. 4F, 394 pp., 39s. 6d.

THIS volume is one of a series intended to provide a comprehensive account of the scientific and technical achievements of the United States of America in the field of atomic energy. It is the work of several well-informed authors, covering many different aspects of the subject implied by the title, and the editor is to be particularly congratulated on having produced a reasonably coherent text despite the widely differing scope and character of some of the contributions, and in view of the many difficulties associated with the publication of work relating to the development of atomic energy. The book deals extensively with the commercial production of heavy water in terms which cannot fail to appeal to the chemical engineer. A large section of the book is devoted to describing laboratory and pilot-scale experiments for different isotope-separation processes, and here again the chemical engineer will find much to interest him, even if heavy-water production is not his main concern. The reviewer is certain that many readers of this work will be surprised to find out how little they really knew about heavy-water production, and how naïve were their conceptions of the processes involved.

The commercial production of heavy water is dealt with in Part 1 of the volume. An introductory chapter explains the principles of the more important methods of separation, which include catalytic exchange between hydrogen and water, distillation of water and hydrogen, and the electrolysis of water. Interesting details are given regarding process costs using the different methods, and the advantages and disadvantages of each process are clearly stated. The opening section on basic principles is, however, somewhat inadequate. The reader is left with a very hazy idea as to the circumstances under which HDO and D_2O are formed, and it is irritating to find trivial slips such as HDO for H_2O at this early stage. Detailed engineering surveys of half- and one-ton per month heavy-water-producing plants based on the electrolytic-catalytic exchange and water distillation processes which were actually operated in the United States are given in Chapters 2 and 3, followed in Chapter 4 by a detailed description of a separation plant based on hydrogen distillation. As the pattern in each of these chapters is similar, it is easy for the reader to refer back to a specific point or to compare one process against another. The presentation is concise, excellent illustrations are provided, and the text is liberally interspersed with tables and graphs giving general plant operating data, heat and mass balances, relevant physical data, and information on electrolytic cells and separating towers. The capital and operating costs for the different processes are gone into in considerable detail. A final chapter in the first section of the book deals briefly with miscellaneous processes for the isolation of heavy water. Attention is given to methods involving the use of separating agents, and to different ammonia-hydrogen exchange processes.

The second part of this book considers laboratory and pilot-plant studies of the more important schemes for separating deuterium. Many readers will find it helpful to study this section before reading the first part of the book, as it contains a wealth of general information on deuterium and on the factors affecting its recovery.

The publication of this well-produced, readable, adequately documented book is particularly welcome at the present time, when many workers are directly or indirectly interested in isotope-separation processes, and it will prove a valuable addition to most scientific libraries.

T. J. WEBSTER.

Physical Chemistry 2nd Edition

by Walter J. Moore
Longmans, Green & Co., 1956. 633 pp., 30s.

THIS comprehensive and readable textbook of Physical Chemistry is certainly a valuable addition to the library of students of chemistry. In scope it is wide, in substance it is adequately weighty, and in the manner of its presentation it is incisive and thought-compelling. From the point of view of the student with a career in the chemical engineering profession in mind this book is not only a clear guide to the principles which underlie many unit operations, but it is sufficiently advanced to serve as a ready reference in the solving of problems of equipment performance.

In this connection the following topics are treated in a way which is highly commendable: vapour pressure, distillation, liquid mixtures, fractional distillation and related equilibria. The law of mass action, velocity of reaction and chemical equilibrium are well done, as also is the application of thermo-dynamics to chemical problems. Heat of reaction receives careful and clear presentation, and electrochemistry is considered over an extensive and varied field. The general nature of colloidal solutions and surface properties are well treated.

On the other hand, it might be said that the topics of interest to the young potential chemical engineer which are not treated fully, if indeed treated at all, are: passivity and corrosion, viscosity of colloids, coagulation, plasticity, gelatinisation, emulsions, water purification, fuels and combustion and industrial gases. These might form the basis of a future book of a similar type.

For the chemical engineering student who desires to supplement his knowledge of general chemistry (and especially those who approach the subject with a first degree in engineering), Chapters 7 to 14 might well be omitted from a first reading. These sections deal in rather more detail than they would require with the kinetic theory, particles and waves, chemical statistics, crystals and the properties of liquids. For students who anticipate a life work in the field of atomic energy, however, Chapters 8 and 9, dealing with atomic and nuclear theory, should be included.

A most useful feature, and one which is highly desirable in any textbook of physical chemistry for the less advanced student, is the inclusion of a varied set of problems at the end of each chapter. For the student working alone or under direction, the solving of problems is probably the best means of acquiring specific knowledge of fundamental principles. Another worthy inovation is the list of reference books on each subject dealt with, and more especially, of published articles from the technical literature, for further study of the topics of the preceding chapter. These are all helpful additions, as also are the excellent line diagrams which are used to illustrate the text.

There is little doubt that this is a textbook most suitable for recommendation, dealing as it does with a field of knowledge already well supplied with textbooks of a readily assimilable character.

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CHROMIUM

VOLUME 1

Chemistry of Chromium and Its Compounds

Edited by

Marvin J. Udy

(Vice-President, Strategic-Udy Metallurgical & Chemical Processes Ltd.)

9¼" x 6" 446 pages Illustrated 88s. net.

Written by thirty experts and edited by one of America's foremost research and development engineers, this valuable two-volume monograph brings together the latest accurate data on the sources, properties, manufacture and use of metallic chromium, chromium alloys and chromium chemicals. The field covered by the present volume is denoted by the sub-title, and volume two will describe the metallurgy of chromium and its alloys.

SODIUM

Its Manufacture, Properties and Uses

by

Marshall Sittig

(Ethyl Corporation, New York)

9¼" x 6" 537 pages Illustrated 100s. net.

Such information as is currently important in the manufacture, handling and use of sodium will be found in this work, together with a critical review of its physical, chemical and thermo-dynamic properties. There are 150 illustrations, including flow sheets, line drawings and photographs of equipment and actual sodium handling operations, as well as 2,000 references to the literature on the subject.

CATALYSIS

VOLUME IV

Hydrocarbon Synthesis, Hydrogenation and Cyclization

Edited by

Paul H. Emmett

(W. R. Grace, Professor of Chemistry, The John Hopkins University)

9¼" x 6" 576 pages Illustrated 100s. net.

The fourth volume in this well-known series will be of particular interest to the petroleum and coal industries. Devoted entirely to the Fischer-Tropsch synthesis, it considers such important topics as the hydrogenation of carbon monoxide and related reactions, methanation, catalytic hydrogenation of coal and tar, and the catalytic cyclization and aromatization of hydrocarbons.

37 ESSEX STREET, LONDON, W.C.2

PLANT EQUIPMENT NEWS

Electronic Check-Weigher

To speed and simplify the process of checking the weight of packed goods in the chemical, food, pharmaceutical and other industries, an electronic check-weigher has been designed by Solartrons. Its special advantage over conventional weighing machinery is speed, and even the portable model allows weighings to be carried out at the rate of sixty a minute. An accuracy of better than 0.2% at the maximum weight capacity is claimed for the machine, yet it is operated by unskilled labour. The operator merely places each package on a weighing head—whereupon one of three signal lights (green, red, and amber for correct, under-, or over-weight) is illuminated. The package is then directed along an appropriate channel. Records of the weighings are made by counters. Nine standard models of the machine are available covering a range of capacities from 3 g to 2 kilos. A model giving a performance of 120 weighings per minute, and designed for incorporation into existing production lines, is also available. The portable model was shown for the first time at The National Pharmacy Exhibition in London recently. **The Solartron Electric Group Ltd., Thames Ditton, Surrey.**

BCE 484 for further information

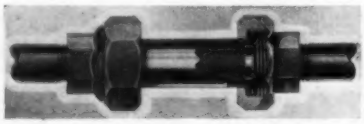
Flame-proof Fire Alarms

Increasing attention is being paid currently to the application of the sections of the Factory Act, 1937, that deal with fire prevention (and which stipulate that provision shall be made for giving "clearly audible" warning in specified buildings in which explosive or highly inflammable materials are stored or used). A leaflet sent out recently by H.M. Chief Inspector of Factories, for example, states that in "high-fire-risk" buildings of more than one storey in height it is "almost inevitable" that electrical alarm systems will be used. It also advises that the systems should comply with the British Standard "Code of Practice for Electrical Fire Alarms". Although such general considerations apply to the chemical industry as to any other industry, in those parts of chemical plants where inflammable vapours are present flame-proof equipment is demanded. To satisfy this need, Gent & Co. Ltd. have applied their experience in making equipment for mines to elaborating a flame-proof call point which is suitable for use in the chemical industry. The equipment is intended to be employed with a flame-proof bell also made by the company. The rugged cast-iron casings necessary for flame-proofing have the incidental advantage of being very resistant to corrosive atmospheres. **Gent & Co. Ltd., Faraday Works, Leicester.**

BCE 485 for further information

Straight-line Strainer

A new straight-line strainer for installation into water, steam, oil, air or gas supply lines is available from Birfield Industries Ltd. The entire straining area is within the flow-way itself, and the appliance is intended to provide a clean,



unrestricted flow of fluids or gases and to protect equipment, valves and controls. The strainer screen is of monel metal of mesh 40 x 40, the tube body is of copper and the couplings of bronze. The screen area varies from 2.32 sq. in. for the smallest (¼ in.) pipe size to 16.35 sq. in. for 1¼ in. pipe size. Aims of the designers were to minimise the need for cleaning, to eliminate unnecessary friction loss and turbulence, and to make the appliance easy to install and accessible from all directions for servicing. **Birfield Industries Ltd., Stratford House, Stratford Place, London, W.1.**

BCE 486 for further information

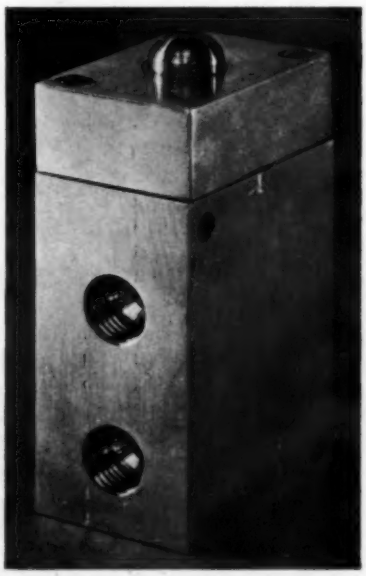
Hose for Liquid Gases

A new kind of flexible hose for conveying liquid oxygen has been produced experimentally by the Flexibles Advisory Service of Compoflex. The new hose is made on a composite principle introduced by Compoflex during the last war, and, the makers claim, by acting as a heat insulator, it will obviate the difficulty of heat feed-back experienced with the use of conventional flexible metal hoses. A greater degree of flexibility at low temperatures is also claimed for the new product—the 4-in. bore size having a bend radius of 3 ft—and, in addition, the hose appears to have a comparatively long working life, a sample having already given constant satisfactory service for over a year. It is equally applicable for conveying liquid nitrogen. So far the hose has been produced experimentally in lengths of up to 20 ft and in bore sizes up to 4 in., but development work is being carried out on bore sizes of up to 8 in. in diameter. The new hose will not be standard stock, as each order will call for "tailor making". **Compoflex Co. Ltd., 23-25 Northumberland Avenue, London, W.C.2.**

BCE 487 for further information

Pneumatic Valve

A new pilot or master valve has been added to the range of Red Ring air equipment. Poppet-operated, the valve is instantaneous in working, and allows for full port flow. A brass spindle, on to which is moulded the poppet faces, moves only $\frac{1}{16}$ in. to open and close the ports by sealing on machined surfaces. Spring pressure holds the poppet on one face, and the valve is actuated by depressing the protruding spindle. The valve can be arranged for lever, palm-button or cam operation. As the spindle assembly can be withdrawn after removing the cover or escutcheon, servicing can be carried out without disturbing pipe connections. There is only one moving part. Arranged for fixing vertically or horizontally, the valve may be used to directly control single-acting air clamps or cylinders or as a pilot valve



to operate a master valve from a remote position. The main sizes are: ¼-in. B.S.P. ports, 1¼ in. × 1¼ × 2¼ in. The valve is already in use on test rigs for producing continuous air impulses in fatigue testing of chemical plant. It is also in

DCE 447 for further information

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PLANT EQUIPMENT NEWS

service at Harwell. **Stuart Davis Ltd., Much Park Street, Coventry.**

BCE 488 for further information

Plastic Drain Cocks

Recent advances in the techniques of casting Ethoxylene mouldings have enabled the development of a range of Ethoxylene resin drain cocks for use in filter presses. Fitted with graphite-filled

plugs so that they are self-lubricating, the cocks are very resistant to the action of acids, alkalis (except aqueous ammonia) and solvents; they resist ageing, and are odourless, tasteless and non-toxic. The cocks are made in sizes from ¼ in.-½ in. bore. with flanged or tapered fixing. Ethox mouldings, cast with Ethoxylene or Epoxy resins, exhibit a mechanical strength of 9/10,000 lb/psi and retain a tensile strength of 2/3000 lb/psi at 120°C. Although the mouldings are tough and are not easily machined, good casting technique ensures that shrinking is minimal and that faces and inserts are accurately positioned. **J. R. Ferguson (Electrical Engineers) Ltd., Tameside Works, Park Road, Dukenfield, Cheshire.**

BCE 489 for further information

A Range of Atomisers

A mechanical screenless mill, the Mikro-Atomiser, for the production of powder of particle size 1-25 micron, is one of the pieces of chemical plant being made in Britain by Bramigk & Co. Ltd. under exclusive licence from their American associates, the Pulverising Machinery Division of the Metals Disintegrating Co. Inc., Summit, New Jersey. Compact in design, the machine gives a guaranteed performance to particle sizes as low as 1 or 2 microns with certain materials. It is available in three sizes with capacities from 5 to 7500 lb per hour. The material is fed into the mill by specially engineered fed mechanisms and, after initial reduction by rotating hammers, it is atomised (dispersed) by an air stream which carries the dispersed particles into a separator wheel where they are whirled about at a high speed. A fan adjacent to the separator wheel draws out the particles of desired fineness and discharges them into a suitable dust collector. Centrifugal force causes larger particles to be returned to the path of the hammers for further grinding. **Bramigk & Co. Ltd., Mikro House, 15 Creechurch Lane, London, E.C.3.**

BCE 490 for further information

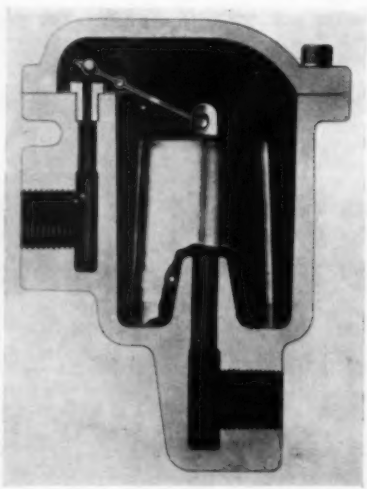
Portable Pipe Bender

Now being produced in Great Britain by E. P. Barrus is the Blackhawk Porto Power S.130, hydraulically - operated portable pipe bender, recently introduced in the United States. Emphasis in its construction is on lightness, the bending frame, swivel and bending shoes being made entirely of rigid aluminium; the bending frame alone weighs only 16½ lb. Among the many innovations in the equipment is the Optik-angle gauge which continuously indicates the degree of bending that has been attained at any moment. A removable top plate makes it easy to set the shoes and position the pipe for bending, and the bending shoes are fixed in place simply with a lock pin. The remote-control unit, comprising hydraulic hand-pump, hose and ram, is readily detachable and can be used with a wide variety of other attachments. Suitable for use with pipes of ½-2-in. in diameter, the equipment is capable of making 90-degree bends at one operation. **E. P. Barrus (Concessionaires) Ltd., 12-16 Brunel Road, Acton, London, W.3.**

BCE 491 for further information

Bucket Steam Trap

A new design of inverted bucket steam trap has been added to the range made by Lancaster & Tonge. The new appliance has a double-leverage action which enables large-diameter seatings to be employed and gives a large capacity-to-size ratio. Constructed in cast iron for

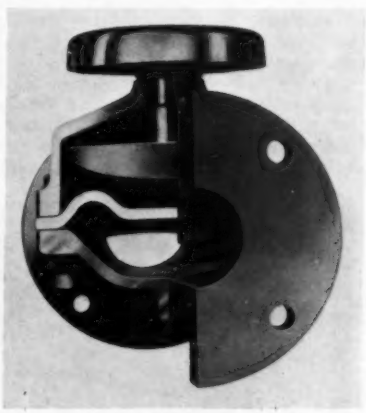


use with pressures of up to 200 psi saturated, it is at present available only in ¾ and 1-in. pipe sizes, but a ½-in. size will shortly be in production. Light in weight so that it can be suspended on pipelines, the ¾ and 1-in. sizes weigh only 7 lb. The ½-in. trap will weigh 4 lb. Except for a copper float, all the internal fittings are of stainless steel, and the makers expect that floats in stainless steel will also soon be available. Tested hydraulically to 400 psi, the traps lift their own condensate, and can be examined and cleaned without breaking pipe joints. **Lancaster & Tonge Ltd., Pendleton, Manchester.**

BCE 492 for further information

Diaphragm Valves

Wynn patent straight-through diaphragm valves are now made for pipe sizes from ¾ in. to 14 in. for pressures up to 200 psi according to size, but valves for higher pressures are being developed. The straight-through flow principle that is employed in the valves renders them self-draining and easy to clean and allows them to offer the maximum resistance to the passage of fluids. The diaphragm of each valve is in its normal, moulded shape when the valve is closed, so that efficient closure is not affected by diaphragm distortion. The body is designed so that it lends itself to



lining with resistant materials, and the diaphragm is attached to the compressor unit and spindle in a way that ensures maximum mechanical strength and ease of replacement. The valves are suitable for use with acids, oils, alkalis, slurries, viscous substances, abrasive suspensions, food products, beverages, gases and most "hard-to-handle" fluids. Standard valves are provided with disc wheel handles, but for larger sizes and heavier duties, cast spoked wheels and tubular spoked wheels are available. Valves are also made with quick-action spindles and lever handles. **Wynn (Valves) Ltd., Granville Street, Birmingham.**

BCE 493 for further informatios

New Plastic Coating Process

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PLANT EQUIPMENT NEWS

available by Horwitch-Smith. It is applicable to Polythene, Perspex, Epoxides and nylon resin powders in twenty-seven colours. The sinter unit has a ceramic base through which a current of air (or nitrogen) is forced under pressure. This aerates an overlying layer of plastic powder into a homogeneous cloud of particles. Heated metal articles immersed in this cloud gather an even coating of the polymer, which can be controlled in thickness within fine limits. The coating has the protective and resistant qualities of the parent substance. The processing takes only a few moments and high production finishing rates can be maintained. As the circulating movement of the plastic powder simulates a liquid state, it is easily possible to cover articles of complex shape. **Horwitch-Smith & Co. Ltd., Pensett, Brierley Hill, Staffs.**

BCE 494 for further information

Mobile Step-ladders

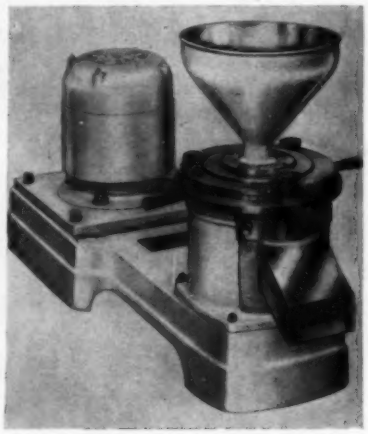
Mobile step-ladders in tubular steel made to designs and heights to suit a variety of industrial requirements are available from the Lenson Engineering Co. Swivel castors at one end of the base make for easy movement of the ladder, and rubber-capped legs at the other end anchor the ladder to the floor under the user's weight. Treads and top platforms are made of Weyroc, a non-slip, hard-wearing material. Four standard designs are made, varying in height (from 2 ft 6 in. to 12 ft 6 in.),

size of platform, and with or without hand rails. Models are available with steps on one or both sides. On step-ladders up to 4 ft in platform-height, each step is 9 in. deep and is large enough to be used as a platform. **Lenson Engineering Co., 326 Humberstone Lane, Leicester.**

BCE 495 for further information

A Versatile Mill

Versatility is one of the chief assets claimed for the new Premier multi-purpose colloid mill, which was also shown for the first time at The National Pharmacy Exhibition. It is intended for emulsifying, dispersing and disintigrating, its motor gives a choice of two speeds, its working surfaces (3-in. carborundum stones or polished stainless-steel plates) can be changed in a few minutes, and it



can be used for continuous output or for processing a batch as small as 4 oz. The machine is compact, occupying only 3 sq. ft of bench space, it is, the makers say, as easy to clean as a saucepan, and it wastes only a few grammes of product, whether the amount processed is pints or tons. The rotor is driven by a belt from the enclosed motor, and with the steel working-surfaces, can be used at any speed up to 12,000 rpm or at up to 8000 rpm when grinding with the stones. **Premier Colloid Mills Ltd., Hersham Trading Estate, Walton-on-Thames.**

BCE 496 for further information

Protection of Blue-prints

A new plastic fluid (B.P.F.) for the protection of blue-prints, work cards, process sheets and other types of document during handling and storage has been introduced by Corrosion Ltd. Treatment with the liquid, which is applied by brushing or spraying, protects the surface of the print or card with a water-white transparent film that bonds with the surface, reinforces the paper or card, and renders it resistant to water, oils, finger marks and to dirt and grease of all kinds. The sprayed B.P.F. film is finger-dry in about one minute from application, retains, it is claimed, its clarity indefinitely, and does not crack or peel. **Corrosion Ltd., 16 Gloucester Place, Portman Square, London, W.1.**

BCE 497 for further information

Electronic Tachometer

Reilly have produced a Tachometer for measuring rotational speed in the ranges 10,000 to 200,000 and 1000 to 20,000 rpm. In operation, light is projected on to a shaft which has been previously marked with a spot, and the reflection from the mark picked up with a photo electric cell, one electrical impulse being obtained per revolution of the shaft. The meter then indicates the number of pulses occurring per unit time, and hence the speed of rotation. The claimed accuracy of indication is better than 2% of the full scale deflection, and is little affected by external conditions such as mains variations, ambient light or location of probe. The probe of the photoelectric cell is of such size that it may be inserted easily into spaces near to shaft surfaces. In addition, an extension piece can be fitted which can bend round corners to reach inaccessible places. **Reilly Engineering Ltd., Pilot Works, Walnut Tree Close, Guildford, Surrey.**

BCE 498 for further information

New Wood Sealer

A wood preservative with water-repelling properties that reduces the absorption of water by, it is claimed, as much as 85%, and the consequent length increase by 72%, has been made available by Cuprinol Ltd. The sealer may be applied to timber by immersion for three to five minutes, by two flowing brush coats, or by liberal spraying, and joinery may be dipped after being made up. Drying time of the preparation varies from about two to three days in warm, dry weather, and from four to six days in cold, damp weather. Putty will adhere to treated timber, but it takes an extra 24 hours to set hard. **Cuprinol Ltd., Terminal House, Grosvenor Gardens, London, S.W.1.**

BCE 499 for further information

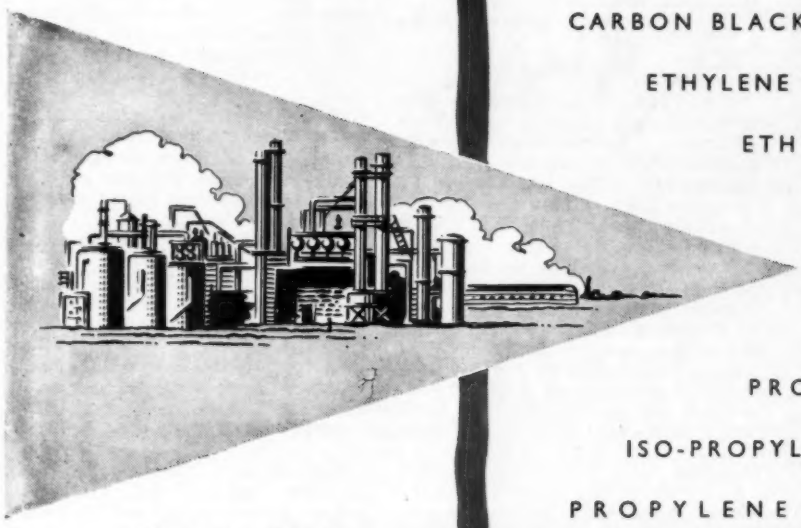
Multi-purpose Thread Restorer

A new model of the Bolt Saver thread-restoring tool has just been brought out by Lawrence Edwards. Intended primarily for repairing damaged threads on bolts, it re-forms or re-rolls the

damaged thread without cutting away metal. The tool can be used on a bench or, where possible, *in situ* on the job. Other applications for the new model, which is available in eight sizes, are as a thread gripper and as a crimper for hose ferrules and "O" clips. The Bolt Saver has been introduced by **Lawrence Edwards & Co. (Engineers) Ltd., Commercial Buildings, Oxford Street, Kidderminster.**

BCE 500 for further information

Chemicals and Petrochemicals



ACETONE

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CARBON BLACK • BUTADIENE

ETHYLENE • ETHYL ALCOHOL

ETHYLENE OXIDE

ETHYLENE GLYCOLS

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If you are planning the manufacture or recovery of one of these products, give us an opportunity to offer you our specialized experience and complete engineering services for your project.

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Process Engineers and Constructors for the Petroleum, Chemical and Petro-Chemical Industries

99, ALDWYCH, LONDON, W.C.2

Affiliated with STONE & WEBSTER ENGINEERING CORPORATION, U.S.A.

PLANT EQUIPMENT NEWS

Four-way Rotor Valve

A new rotor valve for providing easy hand-control of compressed-air cylinders which have a push-and-pull action has been produced by A. Schrader's & Son. The actuating lever of the valve has a neutral position, and movement to either side of this position supplies and exhausts air pressure to and from

alternate sides of each cylinder. Air-tight sealing in the valve is produced by the use of a precision lapped stainless steel disc which slides on bronze rings. Any of the valve's four ports may be selected as the intake; the two ports adjacent to the intake become the cylinder ports, and the remaining one is for exhaust. The valve can be supplied either with side or bottom ports to facilitate the mounting in certain installations. The body is made of cast Meehanite and the working parts are non-corrosive. Any of the working parts can be replaced without disturbing the pipe connections. **A. Schrader's & Son, Division Scovill Manufacturing Co., 829 Tyburn Road, Erdington, Birmingham.**

BCE 501 for further information

Italian Spectrophotometer

Shortly to be made available in Great Britain is the Italian Optica spectrophotometer CF4. Having a bandwidth in the region 2000-6500 A of 1-2 A and a claimed accuracy of ± 0.15% between 0-100% transmission, the instrument may be readily fitted with a range of accessories including a pen recorder, and equipment for examination by nephelometry, flame photometry, fluorescence and reflection. Sole importers are **Joyce, Loebl & Co. Ltd., Newcastle upon Tyne.**

BCE 502 for further information

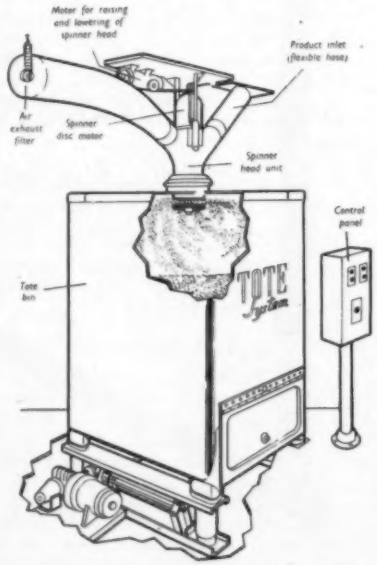
Heating Regulator

A new instrument for regulating the electrical input of industrial heating appliances to infinity between 10% and 100% of the rated input (up to 2 kW) has just been made available by Stabilag. Operating on a conventional principle, but providing a wide range of temperature setting, the Statotherm energy regulator embodies a heating coil energised at mains voltage which heats a bimetal strip. When flexed to an extent determined by the position of the control knob, the strip switches off the apparatus and the current is switched on again through a snap switch after the strip has cooled sufficiently. A supplementary integral bimetal compensator enables the regulator to be used at different atmospheric temperatures without altering the regulating times. The maximum current to the contacts is 10 amps with a non-inductive load. The regulator is available with external or panel mountings. **The Stabilag Co. Ltd., Mark Road, Hemel Hempstead, Herts.**

BCE 503 for further information

Tote System

The Tote bulk-materials-handling system is designed to provide greater efficiency in the handling of powder, granular or liquid materials. The system comprises (1) a Tote bin (designed for easy handling by hand- or power-operated stillage or power truck), which is made in three standard sizes: 42, 74 or 110 cu. ft capacity. The standard filling aperture for each size of bin is 9 in. diameter, and the discharge door is 34 in. x 14½ in. Special gaskets and fasteners are used in both to ensure dust- and weather-tight sealing. (2) The Tote spinner head unit and the Tote jolter are designed to ensure full capacity loading, where required, of fine powders during



filling operations. The accompanying diagram illustrates a typical Tote filler station. (3) The Tote tilt discharger, which tilts the loaded bin to the required angle for discharging into any production or processing equipment. **Pressoturn Ltd., Leam Terrace, Leamington Spa, Warwickshire.**

BCE 504 for further information

New Publications

Corrosion Proof Products Ltd., Great West Road, Brentford, Middlesex, have prepared some notes on the causes of chemical attack on industrial floors and have published these notes in service sheet form (No. 101).

BCE 505 for further information

F. A. Hughes & Co. Ltd. have published two brochures on "Cathodic protection of chemical plant". (Publications 74 and 76.) Copies can be obtained from the company. (Devonshire House, Mayfair Place, Piccadilly, London, W.1.)

BCE 506 for further information

A brochure giving details of the comprehensive engineering and consultancy service offered by **Petrocarbon Developments Ltd.**, 17 Stratton Street, London, W.1, to the chemical and petroleum industries has recently been published.

BCE 507 for further information

List No. 965 is a new brochure by **G. A. Harvey & Co. (London) Ltd.**, Greenwich Metal Works, London, S.E.7, and gives complete information on the die-pressed dished and flanged ends produced by the company.

BCE 508 for further information

An important addition to the series of British Standards for laboratory glassware has been announced. This is for spherical ground-glass joints (B.S. 2761: 1956) and copies may be obtained from the **British Standards Institution**, 2 Park Street, London, W.1. Price 2s.

BCE 509 for further information

Road Research Technical Paper No. 36, "The Sampling and Analysis of Rolled Asphalt and Coated Macadam", has recently been published by H.M.S.O. for **D.S.I.R.**, price 3s. (54 cents U.S.A.), by post 3s. 2d. It outlines the British Standard methods of analysing bituminous materials and examines their accuracy. It then details the procedure necessary to obtain a representative sample.

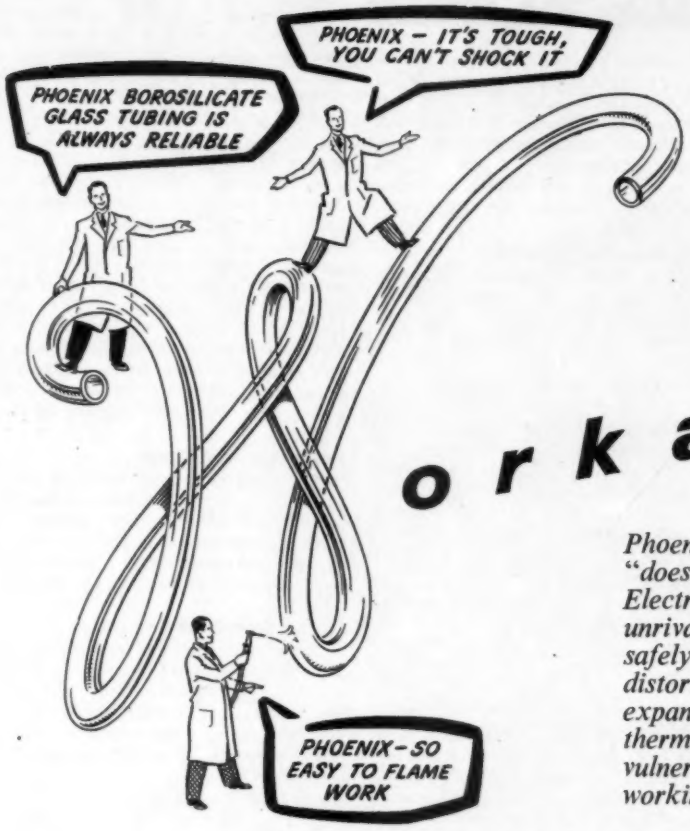
BC7 510 for further information

The 1956 Supplement to the 1955 edition of the A.B.C.M. directory, "British Chemicals and their Manufacturers" has recently been announced. The directory is published at two-yearly intervals and all recipients who completed and returned the postcard included with the 1955 issue are on the mailing list and will shortly receive a copy. Copies are available free of charge from **The Association of British Chemical Manufacturers**, Cecil Chambers, 86 Strand, London, W.C.2.

BCE 511 for further information

Folder D.3 is a four-page informative brochure on the Wynn straightthrough diaphragm valves. Suitable for handling large range of fluids, these valves are self-draining, require no packing, and there is no leakage and, therefore, no contamination is possible. **Wynn (Valves) Ltd.**, Granville Street, Birmingham, 1.

BCE 512 for further information



orkable

Phoenix Heat Resisting glass tubing "does the job" better. Electrically melted, its pliability is unrivalled. It can be shaped—safely—with no fear of fleddage or distortion. The low coefficient of expansion of Phoenix prevents thermal shock and overcomes the vulnerability of this medium in working.

For these good reasons—and many more—the technician at the bench knows the advantage of Phoenix workable glass tubing. He uses Phoenix because, produced by the latest machine methods, it ensures true diameter, true bore and roundness and even wall thickness. The clarity of Phoenix provides—in use—easy check on flow and density, and accurate visual inspection. Phoenix is recognised for chemical stability—absence of any tendency to devitrify—and also for optical and electrical properties of supreme excellence. The mechanical and thermal strength of Phoenix workable heat resisting glass tubing possesses immutable advantages which meet the widest possible range of industrial conditions.

PHOENIX Heat Resisting glass tubing is packed in 14-lb. standard bundles—useful for the small and large user. While standard sizes are available ex stock, special requirements can be dealt with promptly. May we send you our catalogue?

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THE BRITISH HEAT RESISTING GLASS CO. LIMITED
(Technical Dept. C) Phoenix Works, Loxdale St., Bilston, Staffs.
Telephone: Bilston 41701/2/3 Telegrams: Phoenician, Bilston

World of Chemicals

Indian Thorium Factory

During October the Indian Government is to open a new thorium separation plant on Trombay Island, near Bombay. The site has been in use for some time for up-grading thorium ores for the gas-mantle industry. The product of the new plant, however, thorium nitrate, will be employed in the nuclear industry being developed on the island, partly under the Colombo plan.

New Zealand Carbide Industry

The establishment of a calcium carbide industry in the South Island of New Zealand to satisfy home and Australian export markets was recommended by Dr. T. Hagyard, senior lecturer in chemical engineering at Canterbury University, when speaking at a mining conference in Dunedin recently. As New Zealand imported annually 1700 tons of carbide, and Australia one-third of her yearly requirement of 30,000 tons, he suggested that an annual production in New Zealand of 10,000 tons would be suitable.

Canadian Hydrofluoric Acid

Construction is to start immediately on a new large-capacity hydrofluoric acid plant for the Nichols Chemical Co. Ltd. at its Valleyfield, Quebec, works. Aqueous and high-purity anhydrous acid will be produced, both of which, at present, have to be imported from the United States and Europe.

Giant Aluminium Tank

Believed to be largest of its kind ever built, an aluminium storage tank 26 ft high and 128 ft in diameter has been made for the Mississipi River Chemical Co. by the Chicago Bridge & Iron Co. It is intended for the storage of 83% ammonium nitrate solution, and it embodies more than 150 tons of aluminium.

Arab States Potash Company

An agreement constituting the Arab Potash Co. Ltd. was signed in Amman recently by representatives of Jordan, Egypt, Iraq, Syria, the Lebanon, Saudi Arabia and the Arab Bank. The authorised capital of the comoany will be 4,500,000 dinars in 900,000 shares of JD.5 each. The contribution of the Egyptian Government will be 25,000 shares of a nominal value of JD.125,000 and the other Governments are subscribing for a total of 175,000 shares. Of the balance, 200,000 shares are to be offered for public subscription in the Arab states and 500,000 are to be taken up by "Arab Governments and Organisations".

Pure Aromatics Plant

A new plant for the production by a pressure catalytic process of benzene toluene and xylene of high purity is to be built by Koppers Co., of Pittsburgh, Pa., at Clairton, for the United States Steel Corporation. It is expected to be completed during 1957 and will operate under rights acquired by Koppers from the German originators. The benzene produced will have a thiophene content of less than one part per million.

Indian Procaine Production

A plant for Hoechst-Fedco Pharma Private Ltd., a newly-established subsidiary of Farbwerke Hoechst AG., was completed recently in Bombay for the large-scale production of procaine hydrochloride.

Italian Heat Exchangers

Heat exchangers to the design and standards of M. W. Kellogg Co. (a subsidiary of Pullman Inc.) are to be made by Nuovo Pignone of Florence under a licensing agreement concluded recently.

U.S. Peracetic Acid Plant

A new plant for the production of between 25 and 50 million lb. of peracetic acid annually is being planned by the Union Carbide & Carbon, of America.

Purification of Coal Chemicals

Plant for applying advanced petroleum-refining techniques to the production of coal chemicals is being installed by the Jones & Laughlin Steel Corporation, Pittsburgh, Pa. It will employ the Esso Hydrofining sulphur-removing technique and the Universal Oil Products' Udex final purification process. The plant will cost more than $2 million and should be completed early in 1957.

Chilean Nitrate Expansion

The U.S. Export-Import Bank is to grant two credits totalling $27.8 million (£9.93 million) to modernise and expand nitrate production in Chile. An authorisation of $1 million is to be made to the Anglo-Lautaro Nitrate Corporation, and another of $11.8 million to Cia Salitrera de Tarapaca y Antofagasta, the two largest producers.

Canadian Aluminium Triformate

Rhodia Inc., Canada, have made available a new aluminium salt, the triformate, under the name Trinoral. It is intended to replace the diformate and the acetate in the preparation of water-repelling compounds. The salt is said to be stable and not to require the addition of acetic acid.

New Synthetic Latex Process

A process for producing synthetic rubber latex developed recently by B. F. Goodrich & Co., Shelton, Connecticut, enables the daily output of reactors making dry polymer to be increased, it is claimed, from 6000 to 15,000 lb.

Formaldehyde Plant in Mexico

Three million kilos of formaldehyde a year are expected to be produced by new plant to be installed in Mexico by Celanese Mexiana S.A. The plant will also be used for the manufacture of alkalis, resins and detergents which, like formaldehyde, had hitherto to be imported.

Ceylon Refinery Plan

A proposal from a British and American petroleum group composed of Shell, British Petroleum, Standard Vacuum and Caltex to set up a petroleum refinery at the cost of Rs. 175 million in Ceylon has been turned down by the Ceylon Government. The Government is to pursue the possibility of establishing an oil refinery in Ceylon on "more advantageous terms" with other sources or with any of the oil companies that made the original offer.

Australian Acid Plant

Work has started at Rum Jungle on an acid plant for Territory Enterprises which will enable the amount of uranium ore refined in the Territory to be increased considerably. The machinery has been shipped from Great Britain.

Italian Petroleum Concessions

The Italian Minister for Industry with the Superior Mines Council are considering applications from companies wishing to exploit petroleum concessions in Italy. These concern some 9 million hectares in concession areas.

African Oil Exploitable

The Société des Petroles d'A.E.F. (French Equatorial Africa) has announced that oil deposits at Ozouri, twenty miles from Port Gentil, have been shown by test boring to be commercially exploitable, and that production is to start next year at the rate of 100,000 tons a year. The proximity of the deposits to Port Gentil will greatly facilitate the shipment of the oil.

Rubber for Emergencies

A new synthetic rubber, called Coral, which has ben developed in the U.S.A., could free that country in an emergency from dependence upon imported rubber said Mr. H. S. Firestone, Jn., of the Firestone Tyre & Rubber Co., in a speech at Los Angeles on September 25. Although the material had the same essential properties as natural rubber, Mr. Firestone was of the opinion that it would not replace the natural product in the near future.

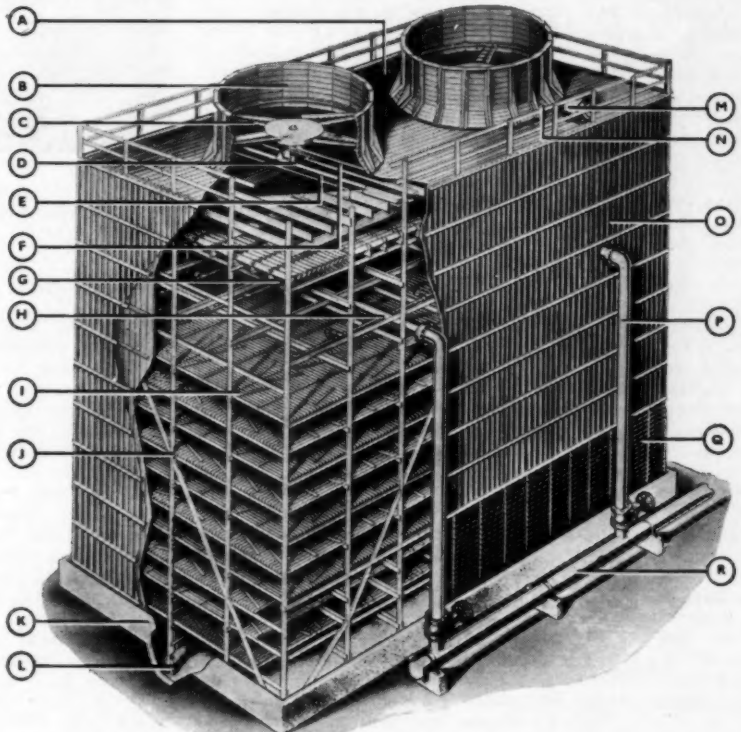
Natural Gas for Canada

By the autumn of 1958 Alberta natural gas will be available in Toronto, and complete distribution in eastern Canada through the Trans-Canada pipeline system will be achieved within six or seven years, said Mr. Howe, Canadian Federal Trade Minister, in Toronto recently. The recent steel strike in Canada and the United States had delayed delivery of the pipe by two months.

BCE 451 for further information

Know the inside story

Year in, year out, all over the world, Fluor Counterflo Cooling Towers are giving spot-on cooling with the minimum of maintenance. What is the inside story of this high standard of performance? It is simply the skills and experience of all concerned with the design and fabrication of cooling towers, with quality control of materials and workmanship, plus attention to the features listed below.



A FAN DECK—Heavy redwood deck at fan level structurally supported for concentrated or distributed loads.

B FAN STACK—A sturdy all timber circular stack with a bell mouthed transition between fan deck and fan stack which increases overall fan efficiency. The stack also serves as a safety guard feature.

C FAN ASSEMBLY—A high efficiency, low speed, axial type, cooling tower air prime mover.

D SPEED REDUCER—A device for reducing fan driver speed to fan operating speed. May be single or double reduction gear or hydraulic motor.

E SUPPORT FOR DRIVER AND SPEED REDUCER—Structural unit support for driver and speed reducer.

F DRIVE SHAFT—Floating shaft and flexible coupling assembly transmit power from driver to gear box.

G DRIFT ELIMINATORS—A multi-pass baffle section minimises the entrained water in exit air stream.

H WATER DISTRIBUTION SYSTEM—Central header, laterals and nozzles operating under positive pressure, ensure maximum initial water break up, uniform distribution, and trouble free operation.

I TOWER FILLING—Grid decks or filling to provide maximum and continuous water break up with a minimum of obstruction to flow of cooling air.

J STRUCTURAL FRAMING—Strength and ruggedness are incorporated in the framework of the tower. The timber tower utilises redwood columns, braces and chords, through-bolted to connector plates. In the concrete tower the main structural framework consists of reinforced precast concrete H-shaped units. Reinforcing bars extending from the end sections into the columns effect a firm and substantial structure.

K BASIN—This collects the tower water and provides structural support for tower.

L BASE CASTING—A cast footing ensures a uniform and solid connection between tower columns and basin pads. In the concrete tower the vertical members are grouted direct on to the base columns.

M FAN DRIVER—A prime mover for fan service that may be an electric motor, gas engine, steam turbine or hydraulic motor.

N SAFETY CUT-OUT SWITCH—With excessive vibration of mechanical assembly automatically shuts down fan driver.

O SHEATHING—A tower sheathing designed for architectural beauty and positive elimination of leaks. The concrete tower precast wall panels are fitted to the outside horizontals by means of supporting lugs.

P RISER—Vertical connector pipe between the manifold and cooling tower header.

Q LOUVRES—An air inlet grill for the purpose of eliminating spray losses and guiding air deep into the tower.

R MANIFOLD HEADER—A hot water pipe manifold distributes water to individual risers and cells.

Head Wrightson Processes design, manufacture and erect prefabricated timber and precast concrete Induced Draught Cooling Towers for all purposes. It will pay you to consult them on your own cooling problems.

Head Wrightson Processes Ltd.

TEESDALE HOUSE, 24-26 BALTIC STREET, LONDON, E.C.1

Offices at: P.O. Box 1595 **Sydney,** P.O. Box 1034 **Johannesburg,** P.O. Box 4 **Calcutta,** and 185 Bay Street, **Toronto.**

Associates in the U.S.A.: The Fluor Corporation Ltd., Los Angeles 22, New York, Chicago, Boston, etc.

387-H

The Month's News in Brief

Thermotank Plastic Engineering Ltd., a new company recently formed by the Thermotank Group, will, it is claimed, shortly produce for the first time glass-fibre reinforced plastics rods, bars, tubes and sheets in quantity and at an economic price. The company states that quantity production will be made possible by the installation of specially designed and patented equipment, machinery and processes at its Chapelhall Works, near Glasgow, and by the development of new manufacturing techniques. Mr. Iain Stewart, chairman of Thermotank Ltd., the Group's parent company, is chairman also of the new concern with Mr. G. Cuming as managing director.

A recent announcement by Mr. N. McKinnon Wood, chairman of the **British Laboratory Ware Association**, states that, as a contribution to the price stabilisation policy of the Government, the Laboratory Furnishers who are members of the British Laboratory Ware Association have decided to stabilise the prices of the laboratory equipment and apparatus, other than chemicals, they manufacture and distribute, for a period of six months from September 1, 1956. This decision applies to the prices, for the home and export markets, fixed by each Laboratory Furnisher individually for its own proprietary goods and for non-proprietary goods and is subject to the costs of materials and wage rates remaining stable.

Midland Silicones Ltd. have announced reductions in the home trade price of the main ranges of their MS 200 silicone fluids and their "Releasil" fluids and emulsions. The reductions, varying from 9d. to 1s. a lb., became effective from September 17.

A new Johnson Matthey associate company came into existence on September 3 when the inaugural general meeting of Etablissements Johnson, Matthey et Cie., S.A., took place in Paris. The issued capital is Frs. 40 million, of which Johnson, Matthey & Co. Ltd. hold 81½%. The company has been formed to develop Johnson, Matthey sales in France.

Arthur D. Little Inc., the American research organisation engaged in fundamental and applied work, will take over the Institute of Seaweed Research at Inveresk, Musselburgh. Purpose of the American activity at Inveresk remains to be demonstrated, but it is anticipated that a fairly large staff will be employed.

Although a number of industries will be actively interested in a new industrial estate, officially opened on September 24 last by Mr. Derek Walker-Smith, Q.C., M.P., Parliamentary Secretary to the Board of Trade, by far the largest single operation will involve **The Plessey Group of Companies,** leading manufacturers of electrical, electronic, hydraulic and nucleonic equipment. The Plessey Co. Ltd. will manufacture a wide range of industrial hydraulic systems, pumps, valves and rams on the estate and plans to allocate space for the stepping up of export contracts.

At an extraordinary general meeting of **George Cohen, Sons & Co. Ltd.** on September 25, resolutions were passed on changes earlier put forward by the chairman and managing director, Mr. Cyril M. Cohen. They have the following effects: (a) a new subsidiary will take over the trading activities of and adopt the name of the parent company (i.e., George Cohen, Sons & Co. Ltd.); and (b) the name of the parent company is changed to The George Cohen 600 Group Ltd., this company becoming a holding company controlling the Group.

Foundry Services Ltd., of Birmingham, departed from the conventional method of opening its new factory. Instead of the usual ceremony performed by a well-known personality, this company invited one thousand of its foundry customers from all over Britain to mark the completion of the new works at Drayton Manor, near Tamworth. The new factory is reported as the largest and most up-to-date plant of its kind in the world for the manufacture of chemical and metallurgical products, the treatment of molten metals and of the moulds into which they are cast.

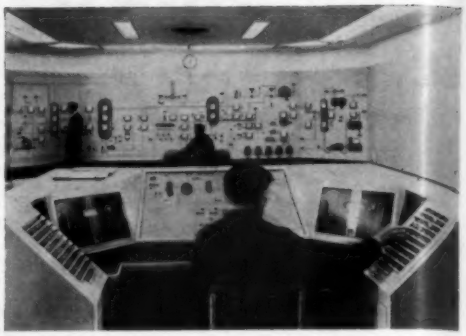
In the control panel of the new fluid catalytic Hydroformer at the Esso refinery, Fawley, near Southampton, the instruments controlling and recording temperatures, pressures and flow rates, etc., are set in positions corresponding to those at which they operate in the plant. The panel was constructed by Foxboro-Yoxall. In the foreground of the picture (this page) the temperature console (by Intigra) shows on dials the temperature of about 200 points throughout the plant. The Hydroformer, which cost £4 million, can process up to 525,000 gallons of oil a day, yet it is operated by only six men per shift. Only one man per shift is present continually, the others attending periodically to log operating conditions.

Victoria Instruments Ltd., a new member of the Pullin Group, has taken over the control of Victoria Instruments, formerly operated by V.I.C. (Bournemouth) Ltd. This new association, it is hoped, will enable the Pullin Group of Companies to provide a more comprehensive and flexible service to meet the varying instrumentation requirements of industry.

The Treasury has made an Order which exempts blast furnace ferro-manganese from import duty for a period ending on March 18, 1957.

The Fuller's Earth Union Ltd. have offered to support for three years a Research Studentship in Chemistry under the direction of Professor R. M. Barrer, F.R.S., in the Chemistry Department at the Imperial College of Science and Technology.

The Pullin Group of Companies have announced the opening of Electrin House, their new London showrooms in New Cavendish Street, W.1. Two of the companies, The Pullin Optical Co. Ltd. and Stanley Cox Ltd., also have their London sales offices and warehouses on the premises.



The control room of the new fluid catalytic Hydroformer at the Esso refinery, Fawley, near, Southampton.

The Stud Welding Organisation of **Crompton Parkinson Ltd.,** 1-3 Brixton Road, London, S.W.9, have informed us that they are always ready to provide details of new applications of stud welding and also any practical assistance or advice that may be necessary. (See article on p. 382.)

Simon-Carves Ltd. have moved from their former London branch offices in Stratton Street into a new and much larger Simon House at 28-29 Dover Street. Tel.: HYDe Park 8191.

Urquhart's (1926) Ltd., of 33 Chase Road, N.W.10, moved on October 1 to larger premises at: 5 Wadsworth Road, Perivale, Greenford, Middlesex. Tel.: PERivale 9511.

Q.V.F. Ltd. have acquired extensive premises at Fenton, Stoke-on-Trent, to which they will in the near future transfer their offices.

The telephone number of **The Hydronyl Syndicate Ltd.** has been changed to KNIghtsbridge 6803.

Atomics

The chairman of the Israel Atomic Energy Commission has announced that Israel will shortly sign an agreement for the construction of a nuclear research reactor in Israel. The French-Israel Agreement on co-operation in research and development work on methods of heavy-water production and on the mutual exploitation of patents has been extended to include the United Kingdom.

Britain, the United States and Canada have agreed to interchange rights in inventions and discoveries in the atomic energy field on which patents were held or applied for by one Government in one or both of the other countries on November 15th, 1955. The agreement will allow use of the inventions in each country by Governments and industry without interference of the other Governments.

Courses on the theory and practice of industrial applications of atomic energy are being arranged for engineers and

We went in for serious junketing....

... and found a better way of collecting the casein

We were asked to suggest the best way to separate the valuable casein content from skim milk. We didn't turn a hair. Instead of getting our heads in a whirl and going into a flat spin, our Technical Advisory Department reviewed the problem and undertook an experimental development programme.

We finally found that by treating the suspension of acid-precipitated casein in a special type of Sharples Super-D-Canter, the separated casein was discharged at 55-60 per cent moisture content, the clarified whey containing less than 0.5 per cent casein.

The Super-D-Canter does the complete job

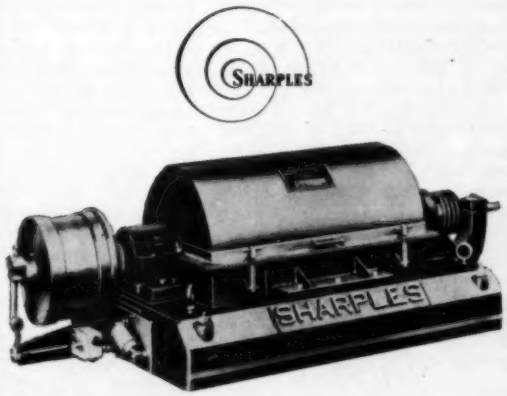
The casein discharged from this first operation contained about 3 per cent ash on a dry (moisture free) basis. To deal with installations where the highest purity casein is required, we developed a further process of acid treatment followed by separation in a second stage Super-D-Canter.

At a later stage in the process the Super-D-Canter and the Super-D-Hydrator are used for the separation of lactose crystals from whey, giving crystals of excellent purity and dryness.

These are only a few examples of the way the Sharples Centrifugal Engineering Service can help you solve a separation problem by the most efficient method. Sharples can offer you a complete range of centrifugal machines for any separation purpose.

Write to us and we'll be glad to send you a copy of our Bulletin No. 653M–Applications of the Super-D-Canter. Or, if you wish, phone Amberley 2251/3 and talk to Martin Trowbridge about your problem.

SHARPLES



The Sharples Super-D-Canter is only one of the wide range of Sharples Centrifuges at your service to solve your separation problems.

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SHARPLES CENTRIFUGES LIMITED, WOODCHESTER, STROUD, GLOS. *Telegrams: "Superspin", Stroud.*

others by **Isotope Developments Ltd.**, Beenham Grange, Aldermaston Wharf, near Reading, Berks.

The forecast that within a decade nuclear power would be giving a "major contribution" to Britain's economy was made by Sir John Cockcroft, director of the Atomic Energy Research Establishment, Harwell, in a public lecture at Sheffield recently. The 1955 plan, which provided for atomic power to do the work of 40 million tons of coal annually by 1975, would probably be carried out earlier than expected because nuclear power stations would have larger outputs than was envisaged.

On the siting of atomic power stations, the present attitude of the **Central Electricity Authority** was to give preference to districts where there was no coal supply, said Lord Citrine, the Authority's chairman, in a speech at Newcastle on Tyne recently. Clearly, it was much easier to carry a few tons of uranium than thousands of tons of coal, he continued, but he did not rule out altogether the building of nuclear stations in mining areas. Nuclear generation for the next ten years was unlikely to be materially cheaper, taking everything into account, than generation by coal or oil, but it might be more economic.

Work on Canada's first pilot nuclear power station was inaugurated by Mr. C. D. Howe, the Minister of Trade and Commerce, at Des Joachims, on the Ottawa River, on September 18. After the ceremony, when visiting the neighbouring Chalk River atomic energy project, Mr. Howe said that the N.R.U. triple-purpose reactor there, which, he hoped, would be in operation next year, would produce substantial quantities of plutonium for sale to the United States Atomic Energy Commission and a "large amount" of radio isotopes for industry, medicine and research. The Des Joachims power reactor would use heavy water as a moderator and a coolant, and it would be fuelled mainly with natural uranium.

People

The degree of Honorary Doctor of Laws of Aberdeen University was conferred on **Mr. H. S. M. Burns,** president of the Shell Oil Co. U.S.A., at a ceremony at Marishal College, Aberdeen, recently.

New members of the board of directors of Newton Chambers & Co. Ltd. are **Mr. S. C. Tyrrell** (assistant managing director, excavator division, since 1954) and **Mr. K. E. Walker** (assistant managing director, engineering division, since 1954). **Mr. S. L. Waide,** general manager, chemicals division, and a local director, has been appointed assistant managing director (chemicals division).

Mr. Kenneth G. Burridge (manager of the chemical engineering section in the central research division of Dunlops) has been appointed works manager of the Fawley, Southampton, plant of International Synthetic Rubber.

Prof. J. D. Bernal lectured at Moscow University recently on the use of X-rays in analysing the structure of biologically important compounds. He has been awarded the title of honorary professor of the University.

F. E. Warner.

A. W. Pearie.

Mr. F. E. Warner has left Carless, Capel & Leonard Ltd. and is now a partner with Cremer & Brearley, consulting chemical engineers, of 17 Queen Anne's Gate, London, S.W.1. Among the profession he is well known through his activities as joint honorary secretary of the Institution of Chemical Engineers, which recently recognised his services with the award of the Osborne Reynolds Medal.

Dr. A. W. Pearce, assistant refinery manager at the Esso Refinery, Fawley, since April 1954, has been appointed to the newly-created post of general manager of refining at the Company's head office in London, with effect from September 1, 1956.

Lord Reith, one time director-general of the B.B.C., has been appointed a director of the British Oxygen Co. Ltd.

Mr. Charles Frederick Huebner, who has been chief buyer for the British Oxygen Co. Ltd. since 1947, has been elected chairman of the Purchasing Officers' Association.

The appointment of **Mr. J. R. Allan** as general manager of the Acme Companies, in which are incorporated Acme Conveyors Ltd., Acme Ventilating Ltd. and Acme Welding & Constructional Engineering Co. Ltd., has just been made. Mr. Allan was at one time a technical officer in I.C.I.'s Metals Division, where he was engaged on production problems in existing and new non-ferrous tube factories. He has also had some considerable experience as an industrial consultant.

S. C. Stewart.

J. R. Allan.

The Carbon Dioxide Co. (a Division of The Distillers Co. Ltd.) announces the appointment of **Mr. S. C. Stewart** as director in charge of the Division. Mr. Stewart, who has been a division director of Carbon Dioxide for some years, is general manager of the Industrial Alcohol Division, and a division director of the British Industrial Solvents Division, of D.C.L.

Mr. R. McKinnon Wood, chairman of Griffin & George Ltd., has been appointed vice-chairman of the committee, under the chairmanship of **Prof. Willis Jackson,** which will advise the Government on the recruiting and training of technical college teachers.

Mr. Keith Ronald Laurence has been appointed to the board of Winston Electronics Ltd., Shepperton.

Rodger, Setterington & Partners, consulting engineers, announce the appointment of **Thomas Neil Stephens** as a new partner in the company.

Mr. Stanley John Wilson, of Cape Town, has been appointed deputy managing director of the Vacuum Oil Co. of South Africa.

Obituary

The death took place at his home in London on September 13 of **Mr. A. M. Low,** the engineer and research physicist who was widely renowned for his scientific work and writing—many of which, however, were for a popular readership. He was 68. Mr. Low was president of the British Institute of Engineering Technology and of the Institute of Patentees. Educated at St. Paul's School, Sperry's College, Glasgow, and the Imperial College of Science and Technology, South Kensington, in early life he made a reputation as a commentator in the technical publications of the motoring industry and as an inventor of improvements in motor car design. During the Second World War he was on the research staff of the Air Ministry and studied a variety of problems, including explosives. He once said, "The greatest discovery is that we know practically nothing about anything".

Coming Events

STOCKHOLM: Plastics Exhibition—October 27 to November 4, 1956.

NEW YORK: 3rd International Automation Exposition—November 26 to 30, 1956. At 500 Eighth Avenue.

CLEVELAND: National Chemical Exhibition—November 27 to 30, 1956.

PARIS: The XIth International Management Congress will be held in Paris from June 24 to 28, 1957. The congress is a triennial event sponsored by the Comité International de l'Organisation Scientifique, the international management organisation of which the British Institute of Management is the constituent member for the United Kingdom.

NEW YORK: 26th Chemical Industries Exposition—December 2 to 6, 1956. At New Coliseum.

LOS ANGELES: Western Metal Congress and Exhibition—March 25 to 29, 1957. At Pan Pacific Auditorium.

LONDON: The first Protective Clothing and Safety Equipment Exhibition will take place at the Empire Hall, Olympia, from May 13 to 17, 1957.

CHICAGO: 2nd World Metallurgical Congress and 39th National Metal Congress and Exposition—November 2 to 8, 1956.